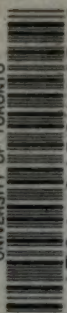



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INHERITANCE, FERTILITY, AND THE DOMINANCE OF SEX AND COLOR IN HYBRIDS OF WILD SPECIES OF PIGEONS

POSTHUMOUS WORKS OF CHARLES OTIS WHITMAN

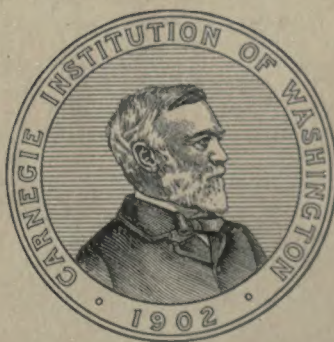
PROFESSOR OF ZOOLOGY IN THE UNIVERSITY OF CHICAGO, 1892-1910; DIRECTOR OF MARINE
BIOLOGICAL LABORATORY AT WOODS HOLE, 1888-1908

EDITED BY

OSCAR RIDDLE

RESEARCH ASSOCIATE OF THE CARNEGIE INSTITUTION OF WASHINGTON

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EDITORIAL STATEMENT.

Seven manuscripts bearing on the subject of this volume, nearly 2,000 pages of breeding record, and about 200 illustrations with accompanying legends comprised the material from which the present volume is assembled.

The first of these manuscripts was written in 1897. It treats of inheritance as limited by sex, and is placed in Chapter XII. Two lectures in 1898 supplied the materials for Chapter XVI and for a fragment of Chapter XI. The third manuscript dates from about 1904, and was slightly revised later. It is the most general and comprehensive treatment of the series and is here made to serve as an introductory chapter. Some tabulations or lists which accompanied this paper have, however, been separated from it and expanded to include studies made after 1904. These expansions treat partly of some crosses made earlier than 1904 but not adequately summarized at that time, and partly of crosses made later by the author and summarized wholly by the editor. These completed summaries now appear as Chapter II. The fourth manuscript, "On the Divisibility of Characters," was written in 1906 and is the basis of Chapter XVII. The fifth, dated 1907 and entitled "Heredity," touches the broader aspects of development and becomes the first section of the concluding statement of Chapter XIV. To this statement have been added three or four pages on "Mendelian Heredity" from a lecture in 1908 and some other materials from the papers next to be mentioned, which have also found their natural place in the same chapter.

A seventh and very incomplete manuscript (R 16, WW 1), consisting largely of short summaries and conclusions drawn chiefly from later studies, was written in 1909 and 1910. The conclusions found here, though disconnectedly set down in about 30 small pages, represent Professor Whitman's most mature and final judgment in regard to his work with the dominance of sex and color, with its control, and with the dependence of this result upon relative "fertility" and "strength" of the germ-cells.

The major task of the editor has been the summarizing of the data on which these conclusions from the work of the author's later years were based and their tabulation and presentation. In most cases this has meant the tabulation of data concerning breeding, quotation from the specific record where possible, and from the notes of the seventh manuscript till this was fully presented; and, finally, undertaking such analysis and discussion as seems absolutely necessary to render it available to students. But such analysis and discussion by the editor have perhaps not been unduly pressed; indeed, the editor believes that, although he has worked much, the reader has yet something to do to avail himself of all that lies in the volume. The results of this effort to present fully these materials may be found chiefly in Chapters II to XIV inclusive. The elaborateness of the detailed tabulations in those chapters—unusual as this method of presentation is—will be found quite necessary because of the nature of the problems treated. For this reason, too, it was deemed advantageous greatly to amplify from the numerous later records the relatively few summaries made by the author and to add many unsummarized earlier records as well.

The close of Professor Whitman's life, late in 1910, left many problems connected with the present volume quite unfinished. The reader is asked to bear in mind that the author did not consider this work concluded—even at the end of the 16 years of his study of pigeon hybrids. It was quite important to the purposes of these studies, (1) that the data for longevity and sex of the 600 pigeons that survived him should be learned and added to his records; (2) that certain untested "mutants" be given a breeding-test. Both of these additional tasks were also accepted by the editor and performed by him—not well, but with the measure of success that has been possible in connection with much other work and under circumstances not at all times wholly favorable.

Collectively the seven manuscripts noted above comprise rather less than 100 typewritten pages. It thus becomes evident that the reader will meet with the words and work of the editor at very many points and that some method must be found for distinguishing in these pages author from editor. In the main, this has been accomplished by the use of certain postscript letters,¹ but in part also by the use of quotation marks, these latter being most used in the designation of short statements, words, or phrases, transcribed from breeding-records and notes. The postscript letters are placed after longer treatments, complete manuscripts, etc. These take the form of (A 1), (C 7/16), (Sh 14), etc., and in textual materials are placed at the close of the writings of the author. In the tables these letters are uniformly placed at the lower right-hand corner of the table. The tables constructed from breeding data obtained by the editor bear his initials in the same position in the table. It is believed that the reader will be able to know or to learn the source of all the statements and materials of the volume. He will bear in mind that all of Dr. Whitman's data were obtained prior to December 1910 and that the editor is responsible for all thereafter.

The postscripts just described have a further and important use. It has been necessary for the editor to make hundreds of summaries of breeding records and to write whole chapters. He hopes—and most sincerely believes—that he has made a faithful transcript of the original records; but so much hangs upon this matter that he has not felt that he cares to act as the sole or ultimate translator or interpreter of these materials. The postscripts given in these volumes are therefore fully given and refer to the "shelving or folder classification" given by Dr. Whitman to the original manuscripts. It is planned to file all of these original materials with the Carnegie Institution of Washington, either at its administration building in Washington or at the Station for Experimental Evolution at Cold Spring Harbor. There they will be available to all interested parties; all of the original records, or any specific ones of these, may there be freely and easily consulted.

In the earlier papers, and also in the one used as an introductory chapter, Whitman was unable to bring forward the remarkable results which were to follow (then only beginning to be observed) bearing on the control of sex in pigeons; but he there (1904) partially outlined a relation between fertility and sex and furnished reasons for the following conclusions: (1) that wild forms of unquestioned purity possess a great advantage over domesticated varieties in a study of some of the

¹This is a continuation of the plan or method adopted for Volume I of these works.

laws of heredity and evolution; (2) that in the study of variation it is necessary to go beyond the biometrician's curve to a knowledge of "the history of the individual phenomenon"; (3) that dominance is a thing of many degrees, and is far from representing a natural law; (4) that in wider crosses, at least, blended inheritance seems to be the more general phenomenon; (5) that very many gradations of "fertility" exist; (6) that apparently some of the most interesting facts of development can be learned only through a utilization of such known gradations of fertility; (7) that males only (or almost exclusively) result from numerous crosses in which fertility ("germ compatibility") is much reduced by a choice of birds widely separated in the pigeon group.

The more important conclusions of the seventh paper—the extended series of short statements, not really in manuscript form—were as follows: (1) that fertility ("germ compatibility" and "germ strength") in its varying degrees is closely associated with the production of sex and color; (2) that fertility varies much in *individuals* of the same species, at different *ages* and at different stages of the *season*; (3) that in general the "stronger germs" arise toward the first of the season and tend to produce males; the "weaker germs" produced in late summer, especially by birds "overworked at reproduction," tend to produce females (and more white color); still later there is a tendency to a production of eggs capable of little or of no development; (4) that there is a predominance of males from the first egg and of females from the second egg of the pigeon's clutch;² (5) that the male goes further in development and arises from a "stronger germ" than does the female; (6) that strength in the parents tends, among pigeons, to produce male offspring; (7) that inbreeding in pigeons leads to the production of weaker germs; (8) that immaturity and old age in pigeons are also associated with the production of weaker germs; (9) that white color, albinism, and color "mutations" may arise, by quantitative variation, from the weak germs incident to inbreeding, old age, and lateness of season; and that such quantitative variations ("mutations") are proved to be of genetic value; and, furthermore, that with pigeons, by simple known means, one should be able progressively to shift the "strength" of their germs so as to secure either a greater or a smaller number of these "mutations."³ In other words, Whitman's later studies constitute a discovery and a partial analysis of certain means of so modifying the germ-plasm as to carry it from one developmental and hereditary capacity to another; and in the light of these results to affirm continuity, quantitiveness, and fluidity regarding the bases of the hereditary characters in question—fertility, sex, and color. This, too, at a time when very many of his fellow biologists have, in large measure, been closely committed to the view that discontinuity, qualitiveness, and fixity are the essential bases of hereditary phenomena.

These latter interpretations are, of course, currently thought to be especially well founded in connection with the heredity of sex. It is of the highest importance, therefore, that sex is one of the characters which has apparently been thus approximately brought under control.

²This is true for many "pure (wild) species"; see a further statement at the close of Chapter XIII.

³A more complete consideration of "mutations" is given in Volume I. They are treated in the present volume only in so far as they are one—a rather infrequent one—of the several phenomena exhibited by "weak germs."

Results which thus strongly impel to so radical a change in opinion concerning the bases of hereditary phenomena will undoubtedly be subjected to the stoutest opposition; the more so, inasmuch as admittedly these studies were not as complete as their author had wished to make them. But it is believed that a full examination of the data of the volume will go very far toward demonstrating that Whitman found material and methods for shifting, changing, or reversing the developmental and hereditary capacities of the germ-cells. The materials of Volume I, which treat evolution as an orthogenetic process, afford also something more than full and complete harmony with this result.

To the general statement of the previous volume concerning a lack of full treatment in these works of the pertinent literature a word should be added here. It is in the present volume that this lack of adequate treatment of contemporary literature will be found most evident. There are three facts to be noted in explanation: (1) the materials of this volume were in a less advanced state of preparation than were those of the companion volumes; (2) the rather plentiful abstracts and notes of current literature which came into the editor's hands were in such form as to raise a question as to their utility, particularly since the main purpose here has necessarily been to present the author's data and conclusions; (3) much of the important work upon the general subject treated here has appeared during the rather long period required for the preparation of these works for publication.

It would be unfair to the author to omit the further record that to him is certainly due the entire credit of having first demonstrated a "shifting of dominance" series. His colleagues, in Chicago at least, were, during several years, quite well aware of his results.

In the preface to Volume I we make specific acknowledgments to those whose assistance, sacrifices, interest, and generosity have made possible the preparation and publication of this work.

OSCAR RIDDLE.

STATION FOR EXPERIMENTAL EVOLUTION,

Cold Spring Harbor, New York, June 1915.

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NANCE OF SEX AND COLOR IN HYBRIDS
OF WILD SPECIES OF PIGEONS

POSTHUMOUS WORKS OF CHARLES OTIS WHITMAN

EDITED BY
OSCAR RIDDLE

VOLUME II

CHAPTER I.

INTRODUCTORY.¹

All domestic breeds of pigeons, of which there are probably not less than 200 distinct kinds, are fertile when crossed and the offspring of crosses are also fertile. The same holds true, so far as known, between the domestic races and the wild rock-pigeons, and this fact is generally held to be a strong indication of common ancestry.

In the case of the wild species of pigeons, of which there are nearly 500, crosses are very often infertile, and fertile hybrids are so rare that Darwin could not find "a single well-ascertained instance of hybrids between two true species of pigeons being fertile *inter se*, or even when crossed with one of their pure parents" (Animals and Plants, I, p. 237). The records since Darwin's time have not furnished the "instance" he vainly sought for.

Even if fertile hybrids were sometimes obtainable, the possibility of establishing an "intermediate" race between two wild species would presumably be very doubtful, since such a result as Darwin points out is extremely difficult even in the case of domestic breeds where the hybrids are perfectly fertile. Darwin says: "Certainly, a breed intermediate between two very distinct breeds could not be got without extreme care and long-continued selection; nor can I find a case on record of a permanent race having been thus formed." (Origin of Species, 5th ed., p. 33.)

The results of experiments with wild species since Darwin's time have been very meager; with comparatively few exceptions, domestic animals and cultivated plants have been preferred to wild species. The very important advantages of natural species for such work have either been entirely overlooked or greatly underestimated.

The difficulty with domestic forms is that they have a complex ancestry which we can never hope to unravel. These forms are themselves the products of a most tangled series of hybridizations,² and hence they give, for the most part, unpredictable results—"reversions," "regressions," "mutations," "sports," *et id genus omne*. With such material each individual, as Galton³ puts it, "should be viewed as the fulfillment of only one out of an indefinite number of mutually exclusive possibilities." The unfulfilled possibilities lurk about in so-called "latent" characters that may sleep for generations and then appear as variations which obey no law except "the law of large numbers," which virtually says: "There is no explanation for the individual phenomenon; be satisfied to know that it is one of many phenomena which always follow that wonderful curve of chance which defined itself by Newton's binomial theorem, and which is so useful in its application to life insurance, pension laws, etc."

Without demurring to the many interesting applications of "the law of large numbers," it must not be forgotten that the individual phenomenon fulfills itself

¹ This paper was written (1904-5) under the caption "Hybrids of Wild Species of Pigeons" — Editor

² Mendel, pp. 25, 26, on variability of cultivated plants.

³ Natural Inheritance, p. 18.

by law, of which Quetelet's curve takes no note. For the discovery of this law, the *history* of the phenomenon must first be ascertained. It is from just this history that the large-number curve diverts attention.

But some will urge that this history is too complex and inaccessible to study. Assuredly it is hopelessly involved in forms whose interminglings have gone on for ages unrecorded. In many wild species, however, the record has run on with such uniformity that the ancestry becomes practically a simple line stretching back through thousands of years without a break. In such cases ancestry is all summed up in parentage, and we can safely say that, knowing the species, we know both parents and ancestors. In crossing two species we may predict the results with considerable detail, for the hybrids do not carry a load of unknown latent characters and the characters they develop can be referred directly to those of the two parent species.

In fact, in pure forms we see neither "sports" ⁴ nor "reversions," but straight and full delivery of what heredity has packed in the germs. The delivery is as precise as the blending of two parental germ-cells can make it. With such forms, in which there has been not only continuity but purity of germ-plasm, we escape endless perplexities, and Galton's problem of finding a precise numerical statement for "the average share contributed to the personal features of the offspring by each ancestor severally" becomes greatly simplified.

In the case of a hybrid between the common ring-dove (*Streptopelia risoria*) and the very distinct Asiatic red ring-dove (*Streptopelia humilis*) we do not have to figure out the "shares" of parents, grandparents, etc. We see the characters of both species so evenly blended in the hybrids and in the offspring of the hybrids when paired *inter se* that we can say that each parent has had an equal share, just as we should describe the color of the mulatto as a "half-tint" and that of the quadroon child of the mulatto and the white as a "quarter tint." The color, as a whole and in each feather and part of a feather, the form and proportions, the size, and even the instincts and the voice, the number of notes, manner, time, and rhythm of delivery, follow closely the same simple formula. It is in such cases that we see, as I believe, inheritance in its purest form, with "chance" phenomena reduced to a minimum and the endless circuities of mixed filial relations excluded.

The "conviction that inheritance is mainly particulate and much influenced by chance" (Galton, *Natural Inheritance*, p. 19), and the conclusions that therefore "the science of heredity is concerned with fraternities and large populations rather than with individuals," shows to what extremities we are pushed as the result of attending too exclusively to forms of highly mixed ancestry. Nothing in the experience of breeders is more certain than that long-continued, promiscuous inter-mixing of stocks leads to instability and chaotic confusion in the transmission of characters. Characters are thus, as it were, churned up until their typical distribution in the developing organism is more or less deranged. Of course, chance results are then conspicuous and laws are masked under distortions. Mixture is random, characters are placed in unnatural relations, broken up, and scattered as if sprinkled from a pepper-box. The appearance is very "particulate" and the "large-number" curve is perhaps a refuge to be grateful for. Such conditions

⁴ A very few cases of "mutations" were later found. They are described in this volume and in Volume I.—EDITOR.

are graphically pictured in the colors of the thoroughly mongrelized domestic pigeon, and even in some of the so-called "pure" breeds, described as "mottled," "mealy," "grizzled," "splashed," "spangled," "well-broken," etc.

It would seem to be obvious that *purity* of stock is the first essential for eliminating "chance" phenomena. Purity is not to be found in domesticated forms, nor yet in wild species that show intermingled forms. The terms "pure," "true," "constant," as used by breeders, mean nothing more than a degree of uniformity capable of being artificially maintained by careful selection and mating. The best almond tumbler, for example, according to Fulton⁵ (p. 155) "will only remain what it should be for at most two seasons."

The purity requisite for scientific purposes is the self-sustaining purity found only in unmixed natural species, such as are represented in large numbers and convenient forms in the wild pigeons. Over 450 distinct species are recognized in Salvadori's "Catalogue of Birds in the British Museum." In this large group, undoubtedly arising from a single root and having much apparent homogeneity, the species are remarkably distinct, even in nearly allied forms. Sometimes two species are so nearly alike in size, form, and color that they appear, even to the trained eye, to be one and the same. When the two are brought together in life, fairly sharp distinctions are quickly detected in the voice, proportions, color, and behavior, and crosses give hybrids that demonstrate specific distinctness. The wild ring-dove of Japan and China (*Streptopelia torquatus*)⁶ and the cage ring-dove (*Streptopelia risoria*) are two such species. As *St. risoria* is not known in a wild state and is probably of African origin, and as *St. torquatus* enjoys geographic isolation from it and its nearest relatives, it is safe to conclude that the two species are pure with respect to each other, and their purity as regards other sources is not open to doubt. The hybrids from these two species are intermediates, but incline somewhat towards *torquatus*, as is particularly manifest in voice and color.

Although *St. torquatus* appears to be somewhat prepotent in crosses with *St. risoria*, its superiority does not reach exclusive dominance in a single namable character. Mendelian dominance does not exist, and the law that fails in the first generation of course can not hold in the second. *Dominance, so far as my observations go, is a thing of many degrees, and is far from representing a natural law.* Even allowing that it is a rigid rule in one or a few species, that would not raise it to the rank of a law, if the test of a law is universal application.

In crossing the wild passenger-pigeon (*Ectopistes migratorius*) with the cage ring-dove (*St. risoria*), the hybrids have so far been invariably remarkably close intermediates, and without exception sterile males. If this rule should hold in experiments continued for a hundred years, it would still have no claim to being a general law. At most it would only be a proved rule for a particular cross; in another cross the blending may be only partial, both sexes may appear, and one or both be fertile. The rule would be broken in every point, and obviously two contradictory rules do not make one valid law. The regularity which we may discover in individual cases, no matter with what detail, accuracy, and constancy fulfilled, rises to the dignity of law only when referred to causes or processes of a general nature.

⁵ Fulton's Book of Pigeons, London, 1895.

⁶ *Streptopelia douraca* was later used as the proper name of the oriental ring-dove. See Chapter XVI: -EDITOR.

We are undoubtedly justified in assuming that some principle underlies such definite results of hybridization as Mendel discovered in peas. But that principle, if it be dominance, as supposed by Mendel,⁷ can only be a principle of as many degrees and exceptions as dominance itself, from which it is clear that dominance can be no more than an accident, and an accident that as yet we can discover only by the resulting segregation phenomena.

Segregation is thus bound up with dominance, following it in all its degrees and exceptions. A "law" must level all contradictions between dominance and blended inheritance. At present the latter seems to be the more general phenomenon.

Dominance, strange to say, seems to disappear in blend between widely distinct species, and to come more into view as the species are more closely related.⁸ De Vries goes so far as to make Mendel's laws a test for species, forms subject to them being thus shown to be of one species (1902, p. 141). This seems strange if dominance means antagonism of characters, since the more highly differentiated characters might be expected to stand farther apart and to be more and more difficult to blend. What, then, can be the nature of dominance? Then, too, the less dominance we see in the first generation of hybrids, the more segregation we see in the second.

In such questions as we are dealing with—dominance, segregation, ancestral and parental influence, etc.—it would be an advantage to know as intimately as possible just what the specific characters are, how they are related phylogenetically, whether they represent ancient or recent acquisitions. This history of characters will presumably assist in understanding the results of crossing.⁹

It is desirable also that the characters for study be of a definable kind—localized differentiations rather than whole characters, such as "self" or "whole" colors. The latter are of interest, but do not tell us so much as the regional character.¹⁰

The infertility of crosses is not to be confounded with sterility; it stands rather for various degrees of specific incompatibility between the germ-cells of the cross-mated birds. We do not know what this incompatibility means, but it is certain that it is in no way accounted for by external causes, such as difficulties in copulation or in the conjugation of the sperm and ovum. In many cases the development of the egg is carried far enough—to the formation of a blood-circle—to show that the sperm has entered the egg and fertilized it. The development may halt at this point or earlier, or be carried on to any later stage, even to hatching. The young bird may die within a few hours, or live on, apparently doing well, for several days, a week, or more, and then drop off as if life were a time-fuse calculated to end at a definite moment.

⁷ See Mendel, p. 27, "If furthermore," etc.

⁸ The blond ring-dove and the white ring-dove may be taken as two most nearly related forms, and the Japanese turtle-dove and the domestic dove as two wide-apart species, belonging to two different families according to systematists.

⁹ The data on this subject will be found in Volume I.—EDITOR.

¹⁰ See Weldon, *Biometrika*, 1, 2, Jan. 1902, p. 228. Weldon here gives (p. 245) the history of the Telephone pea, and says it exhibits "a gradual series of transitional colors from a deep green to an orange yellow." "Peas of all the transitional forms figured (6) were numerous." They show also "every conceivable condition" between smooth and wrinkled forms (p. 246). According to Mendel, a hybrid pea, like Telephone, should after at least 25 generations contain only round peas, if "round" is dominant (p. 246). "The law of segregation, like the law of dominance, appears therefore to hold only for races of particular ancestry" (p. 251). De Vries and von Tschermak have offered formulae for other plants, but they have just as little prospect of proving valid generally as Mendel's formula (p. 252).

The term of development to which we have just made reference often lies within such definite limits that, once ascertained, we may know about what to expect in future trials with the same birds. In the pigeons I find that the length of the course to be run, although varying widely, is, on the average, cut shorter and shorter as the crosses range from close allies to more distantly related species.

The causes of infertility in crosses—or, more correctly, the causes of fertility in lower and lower degrees as the divergence between the crossed species increases—have yet to be investigated. What connection, if any, do such phenomena have with the formation of so-called “pure” germs in hybrids? If “purity” is a thing of degrees, as it most certainly is, do the degrees rise or fall with fertility? Furthermore, if degrees are so numerous as to appear to flow together, can a few cases of approximate “purity” be claimed as a law? Do higher degrees differ in kind from lower, and so justify the assumptions of “discontinuity,” “mutation,” etc.? If two wide-apart degrees are found with no intergrades, how easy to conclude that they are both “sports” without genetic connection.

In dealing with such questions, the first requisite is material suited to give definite answers. In this respect the pigeon group is an ideal one, for it is composed of so large a number of closely graded species that it must afford some positive evidence of “flowing degrees,” if such exist, and at the same time give us the directions of rise and fall in a considerable number of well-defined differential characters. For the experimental side of the study we require not only species that will cross with continued fertility, but also species that will cross with varying degrees of fertility. Both are essential and both are represented in this group in exceptional abundance.

As there are between 400 and 500 distinct species of wild pigeons, and as nearly every species may be presumed to be fertile with at least one other species, the number and variety of fertile crosses possible must, at the lowest estimate, be quite large. But the number is probably many times larger, for a single species may be fertile with all or most of its congeners and, in lower degrees, with members of other genera and even of other families.

The common ring-dove, for example, is fertile not only with some dozen other species of its genus (*Streptopelia*, collared doves), but also in lower degrees with the typical turtle-doves, as two successful tests—one with the European turtle-dove (*Turtur turtur*) and another with the Surate turtle-dove (*Spilopelia suratensis*) of Burma and the Malay Peninsula—sufficiently attest.¹¹ In still lower degrees it is fertile with the mourning-dove (*Zenaidura carolinensis*), with the white-winged pigeon (*Melopelia leucoptera*), and with many races of domestic pigeons.

How much farther the fertility of this species may extend remains to be tested. Some other ring-doves, as the wild species of China and Japan (*Streptopelia doucasi*) and the red ring-dove (*St. humilis*) of the same countries, give evidence of equally strong fertility in crosses. The Oriental or Japanese turtle-dove (*Turtur orientalis*) promises an even wider range of fertility, as I have obtained one fertile hybrid between it and *Columba livia domestica*. This is, I believe, the most remarkable case of fertility hitherto recorded. It would certainly be difficult to match it in any other group of the higher animals. The offspring of this hybrid exhibit to

best advantage some of the most interesting phenomena of heredity, and I am convinced that this is the kind of material now most needed in attacking the all-embracing subject of the evolution of species.

The wild species of pigeons, in themselves and in connection with the domestic pigeons, offer a boundless field for the experimental study of variation and heredity. The many and closely grading species, with many sharply defined characters; the wide range of fertility, adapted to many modes and lines of experiment; the perfection and ease of control; the fulness and extent of the background of knowledge available in many cases; the possibility of knowing in advance the main facts of ancestry and the position of the species in the genealogical tree of the group, are all important advantages for such study. (A 1/7)

CHAPTER II.

CROSSES AND FERTILITY OF WILD SPECIES OF PIGEONS.

The species employed with some success in crossing are the following:

Feral species.

1. Oriental turtle-dove	<i>Turtur orientalis</i> Lath.
2. European turtle-dove	<i>turtur</i> Linn.
3. Chinese turtle-dove	<i>Spilopelia chinensis</i> Seep.
4. Tiger turtle-dove	<i>tigrina</i> Temm.
5. Surate turtle-dove	<i>suratensis</i> Gm.
6. Senegal turtle-dove	<i>Stigmatopelia senegalensis</i> Linn.
7. Blond ring-dove	<i>Streptopelia risoria</i> ¹ Linn.
8. White ring-dove	<i>alba</i> Knip and Temm.
9. Japanese ring-dove	<i>dourina</i> Hodge.
10. Red ring-dove	<i>humilis</i> Temm.
11. Cape ring-dove	<i>capensis</i> Sundev.
12. Damar ring-dove	<i>damarensis</i> Linsch and Hartl.
✓ 13. Passenger-pigeon	<i>Ectopistes migratorius</i> Linn.
14. Mourning-dove	<i>Zenaidura macroura</i> ² Linn.
15. Zenaida-dove	<i>Zenaida macroura</i> Ridgw.
16. White-winged pigeon	<i>Melopelia leucoptera</i> Linn.
17. Wood-pigeon	<i>Columba palumbus</i> Linn.
18. Tibetan pigeon	<i>leucotis</i> Vig.
19. Guinea-pigeon	<i>guinea</i> Linn.
20. Wild rock-pigeon	<i>livia</i> Bonn.
21. Stock-dove	<i>oenas</i> Linn.

Domestic races crossed with feral.

22. Fantail (black)	<i>Columba laticauda</i> .
23. Fantail (white)	<i>laticauda</i> .
24. Homer	<i>tabellaria</i> .
25. Tumbler	<i>gyras</i> .
26. Archangel	<i>illyrica</i> .
27. Mondain	<i>admista</i> .
28. Chequered rock	<i>affinis domestica</i> .
29. Two-barred rock	<i>livia domestica</i> .
30. Owl-rock hybrid	<i>turbata</i> × <i>livia</i> .

Besides these primary crosses, most of the hybrids have been bred, or, where not fertile, the fertility has been repeatedly tested. In other cases fertile hybrids have been crossed with hybrids of other species, and as many as five species thus combined in a final hybrid. (A 1/7)

Other wild species bred in captivity.

31. Spotted pigeon	<i>Columba maculosa</i> Temm.
32.	<i>rufina</i> Temm.
33. Band-tail	<i>fasciata</i> Sav.
34.	<i>gymnocephala</i> Temm.
35. White-crowned pigeon	<i>leucocephala</i> Linn.
36. Eversmann's dove	<i>eversmanni</i> Bp.
37. Inca-dove	<i>Scardafella inca</i> Less.
38.	<i>Leptoptila reichenbachii</i> Pelz.
39.	<i>brachyptera</i> G. R. Gr.
40.	<i>chloranthena</i> (?) Ggl. and Salv.
41. Crested pigeon	<i>Ocyphaps lophotes</i> Temm.
42. Zenaida-dove	<i>Zenaida macroura</i> Bp.
43. Bronze-wing	<i>Phaps chalcoptera</i> Lath.
44. White-faced pigeon	<i>Leucosarcia picta</i> Lath.
45. Red-shouldered dove	<i>Geopelia humeralis</i> Temm.
46. Peaceful ground-dove	<i>tranquilla</i> Gould.
47. Barred ground-dove	<i>striata</i> Linn.
48. Diamond-dove	<i>cuneata</i> Lath.
49. Quail-dove	<i>Geotrygon</i> sp.
50. Florida ground-dove	<i>Chamæpelia passerina</i> Linn.
51. Ground-dove	<i>talpacoti</i> Temm.
52. Bronze-wing	<i>Phaps elegans</i> Temm. SS 29.

¹ Bonaparte, *Consp. Av.*, 11, 63, 1854. See Chapter XV for full discussion. —EDDTON.

² Two specific names are in use for the mourning-dove. The A. O. U. Check-list adopts *macroura*, given by Edwards (*Birds*, 1, p. 125, 1750) and accepted by Linnaeus (*S. N.*, ed. x, 1758). This pigeon, however, has been almost universally known, both in Europe and America, as *carolinensis*, a name bestowed by Catesby (*Car.*, 1, p. 24, 1754). The use of this name has been sanctioned by an overwhelming majority of authors and in all the standard works on pigeons. Further treatment of the definition of several of the species of *Streptopelia* here listed is given in Chapter XV and in Vol. I. —EDDTON.

Some breeding behavior which is quite as instructive as that secured from crosses has been obtained from the simple breeding (*i.e.*, without crossing), and from the inbreeding, of individuals of the same species or race. This is true for both wild species and domestic breeds or races of pigeons. Among the latter are the pouters, homers, and barbs. The zenaidas, ground-doves, Oriental or Japanese turtles, and guinea-pigeons are the wild species of most importance in this respect.

In this type of mating some of the effects of age and season on germs and offspring are displayed free from the complications added by hybridization, while, on the other hand, the results thus obtained prove most helpful in the understanding of similar phenomena obtained in the crosses.—(EDITOR.)

The following primary crosses (not including crosses of varieties of domestic pigeons) have been made:

List of crosses.

Cross.	Description.	Relation-ship.	Sex of hybrids.	Remarks on hybrids.
	<i>Male.</i> <i>Female.</i>			
1	C. admista × T. orientalis	Fam.	8♂ ¹	Infertile.
2	C. tabellaria × T. orientalis	Fam.	5♂, 1♀	No test for fertility.
3	C. affinis domes. × T. orientalis	Fam.	2♂, (1♀?) ²	1♂ fertile w. dom.
4	Orientalis-ris. × C. tabellaria	Fam.	1♂	1 no gonad; 1 indif. behav.
5	C. gyrans × risoria-alba *	Fam.	11♂	Not long lived.
6	Ect. migratorius × alba-ris × ris-alba	Fam.	8♂ ³	All interm.; infertile.
7	St. alba	Fam.	2♂	Shade paler; infertile.
	St. risoria	Sub-fam.	16♂	2 no gonad; infertile.
	risoria × alba *	Sub-fam.		1 hatched; short lived, many eggs.
8	Zen. carolinensis × alba-ris × ris-alba *	Sub-fam.	2♂	6 others hat.; 3 wk. to 30 mo.
	Za. vinaceo-rufa *	Gen.	2♂, 4♀	Fertile.
12	Vinac.-carolin. × St. alba *	Sub-fam.	1♂ or 1♀	+2 adults w. no gonad.
13	St. risoria *	Sub-fam.	3♂ + 1?♂	Gonads minute in adult
14	Complex carol vinac. hyb. × ris-alba × ris-alba *	Sub-fam.		1 adult w. no gonad.
15	T. turtur *	Sp.	7♂, 4♀	♂ fertile.
16	St. alba *	Gen.	37♂, 37♀	Partial fertility.
17	St. risoria *	Gen.	4♂, 6♀	Partial fertility.
18	Orientalis-alba × St. risoria		1♀	Infertile.
19	Orient-ris-tur-alba × alba-orient		2 hermaphrodites, predom. ♀	
20	Orientalis-risoria × ris-tur-alba		2♂, 1♀	♂ fertile.
21	Orientalis-risoria × alba		7♂, 4♀	♂ fertile.
22	T. turtur × T. orientalis *	Sp.—	7♂, 14♀	Fertile.
23	Turtur-orientalis × hum. × hum-ris	Gen.	2♂, 3♀, 1? hermaphrodite.	♂ fertile.
24	Tur-orient-hum-ris × St. alba		1♂	?; not tested.
25	Tur-orient × hum-ris × St. risoria		7♂, 1♀	1 adult w. no gonad.
26	Alba-ris × ris-alba × T. turtur	Gen.	3♂, 3♀	Fertile.
27	Alba-ris × ris-alba × Sp. suratensis	Gen.	1♂	Fertile with alba.
28	Risoria-humilis × alba			1 full-term embryo.
	T. orientalis *	Gen.	8♂, 6♀	Partial fertility.
	Sp. chinensis	Gen.		No young raised.
29	St. risoria × St. alba	Sp.—	2♂, 6♀	Fertile.
30	St. risoria × St. douraca	Sp.	8♂, 5♀	(+1?♀) fertile.
31	St. risoria × St. humilis	Sp.	4♂, 3♀	(?=7♂, 4♀) fertile.
32	St. risoria × alba-orientalis		1 acts as ♂; 3 w. no plain gonad.	
35	Alba-ris × ris-alba × C. tabellaria (?)	Fam.	1♂, 1?♀	Lived few da. to 4 yr.
36	St. risoria × St. risoria	Sp.—	7♂, 7♀	Fertile.
37	St. alba × St. humilis	Sp.	18♂, 18♀	Fertile.
38	T. orientalis *	Gen.	60♂, 43♀	Partial fertility.
39	Humilis-risoria × St. alba	Sp.	4♂, 3♀	Not tested.
40	Alba-risoria × C. tabellaria *(?)	Fam.	—♂, 2?♀	(4?) short-lived.
41	St. douraca × St. risoria	Sp.	2♂, 3♀	Fertile.
42	Risoria-alba × St. douraca	Sp.	2♂, 4♀	Fertile.
43	Ris-alba-surat. × St. humilis		1♂	? not tested.
44	Turtur-orientalis ⁴ × alba-risoria	Gen.	1♀	3 alive.
45	C. domestica × St. risoria	Fam.		2 yg. short-lived.
46	Sp. chinensis × Sp. suratensis	Sp.	1♂, 1♀	Short-lived.
47	Sp. suratensis ⁴ × St. risoria *	Gen.—	1♂, 1♀	(+1♂, +2?♀) fertile.

¹ Professor Whitman listed 8 here in a summary (A 1/7); the editor has the original data for only 6.

² Ovary very rudimentary.

³ The records (XS 4) show 8 males; "one acted as a female, but was killed by Dr. Guyer and found to be a male." These records also show 2 males from the *migr.* × *alba* cross.—EDITOR.

⁴ These (two) additional crosses were obtained (1911 and 1915) by the editor with the birds of the Whitman collection.

* The crosses marked with an asterisk (*) have been added from the records, by the editor, to an early summary (A 1/7) made by Professor Whitman.

List of crosses (continued).

Description.		Relation- ship.	Sex of hybrids.	Remarks on hybrids.
Male.	Female.			
48-49	Stig. senegalensis × { St. alba *	Gen. -	10♂, 6♀	Fertile
	St. risoria *	Gen. -	7♂, 3♀	(1 ♂ or hermaph.)
50-51	Senagalensis-alba × { Sp. tigrina *	Gen. -	2♂, 1♀	(2?) lived 2 to 5 mo.
	St. risoria *		10♂, 1♀	1 sex abnormal
52	Senegalensis-ris × St. alba *		1♀	Lived 4 years
53	Orient-tur-ris-alba × St. capicola *			Uncertain.
54	St. humilis × St. risoria	Sp.	11♂, 12♀	Fertile
55	St. damarensis × risoria-alba *	Sp.	2♂	Not tested
56	Za. vinaceo-rufa × Zen. carolinensis *	Gen. -	9♂, 6♀	Fertile
57	Mel. leucoptera × alba-ris × ris-alba	Sub-fam.	1♂	2?; infertile
58	C. turbata × C. livia (or domest.)	Sp.	10♂, 8♀	Fertile
59	C. leuconota ⁵ × C. livia	Sp. +		1 hat., died young
60	C. ceras × C. livia domest.	Sp. +	3♂, 2♀	Fert. w. domestication
61	C. admista × C. palumbus	Sp. +		2 died at 4 to 7 da.
62	Laticauda-risoria × C. gyrans *			3 not long lived
	C. tabellaria	Sp. +	3♂	8 hat., 7 lived 1 to 19 da., 1 lived 15 + mo.
63-64	C. guinea (No. 1) × { C. turbata-C. livia	Sp. +		8 hat.; lived 5 to 10 da.
	C. affinis domestica	Sp. +	1♂, 1♀	9 hat., 1♀, 4 inf., 1♂ fertile
65-65b	C. guinea (No. 2) × { C. tabellaria	Sp. +	2♂, 4♀	Lived 10 to 20 mo.
	C. turbata-C. livia	Sp. +		4 hat., lived 7 to 10 da.
66	Turbata-tabellaria × turtur-orientalis		10♂, 7♀	Lived 1 da. to 3 mo.
67	C. tabellaria × St. risoria	Fam.	2♂	Infertile
68	C. laticauda (white) × St. risoria	Fam.	1♂	Weakly fertile
69	C. gyrans × St. risoria	Fam.	7♂	Infertile
70	C. illyrica × St. risoria	Fam.	1♂	Lived few da., inf.
71	C. admista × St. risoria	Fam.	6♂	Infertile
72	C. laticauda (black) × St. risoria	Fam.	21♂	Infertile ⁷

⁵ Cross made (1911) by the editor.⁶ It does not now seem certain that this bird was a female; it acted as one, but laid no eggs. I find no record of an autopsy.—EDITOR.⁷ The data for this cross as found in a summary in A 1/7; the original data are not available to the editor.

The crosses marked with an asterisk () have been added from the records, by the editor, to an early summary (A 1/7) made by Professor Whitman.

STATEMENT BY THE EDITOR.

It will be seen that a number of hybrids are here used as members of primary crosses. The method used in the preceding lists and throughout this volume of naming or designating hybrids, therefore, requires at this point a word of explanation.³ This method will probably become clear from an explanation of a single example. In cross No. 23 of the above list the composition of the two birds entering the cross is expressed as follows: *Turtur-orientalis* × *hum.* × *hum-ris*. That part of the formula which is written in front of the largest × (or × ×) gives the composition of the male used in the cross; in this case *T. turtur* and *T. orientalis*. The order of these two specific names indicates at the same time that this hybrid sire has a *turtur* father and an *orientalis* mother, since the designation of the male parent always precedes that of the female parent in every formula and in every part of a formula. Similarly the portion of the formula written after the largest × (or × ×) gives the composition of the female, in this case *humilis* × *humilis*.

³ This is only in part the method used by Professor Whitman in making his records. He used two methods, in the later years he employed a numerator-denominator formula in which the numerator gave the composition of the father and the denominator that of the mother. He used an *initial*, or single letter, to designate a species and grouped these symbols somewhat as in the method described above. His description of a bird of the composition of the one given above had the following form: $\frac{T-O}{H-h-s}$. It seemed to the editor that this sort of nomenclature, though very convenient for making the records, is not well suited to the purposes of publication.

risoria. The arrangement of this part of the formula indicates that the female (used as dam in this cross) had a pure *humilis* father and a mother which was hybrid between *humilis* and *risoria*. The hyphen (—) is used instead of a small symbol (×) to indicate the more remote unions or matings. The hybrid that results from the cross of the two birds of cross No. 23 just cited will itself be designated by the formula exactly as written above, *i.e.*, *turtur-orientalis* × *humilis* × *humilis-risoria*.

In all of the tabulated breeding records of the succeeding chapters the composition formula for the male bird which is used as sire is written as the numerator and that of the female as the denominator of a fraction. It is believed that as the reader proceeds he will find the method followed here is an easy and natural one and that it gives completely and in reasonably compact form the pedigree of the bird.

Included in the preceding list of primary crosses are the data for the number of males and of females produced by each cross. A general statement concerning the fertility of the hybrids is also given for most of the crosses. In addition, it has been thought well to give the degree of relationship of the two forms crossed, *i.e.*, whether they are of specific, generic, subfamily, or family distinction. In some of these cases the degree of distinction has been more fully indicated by plus (+) and minus (—) signs placed after the words "species," "genera," etc. The designation "gen. +" then is intended to state that the two forms of a particular cross belong to different genera and that these two genera are perhaps more unlike than are those genera designated "gen. —."

Table references to 72 primary crosses.

Cross.	Table.	Cross.	Table.	Cross.	Table.	Cross.	Table.
1	1, 5	19	62	38	23, 24, 29, 30,	56	91
2	2, 3, 4	20	54		42, 43, 44	57	166
3	4	21	54	39	141	58	82, 83, 83a
4	118	22	7, 7a	40	116	59	166
5	114	23	60	41	134	60	85
6	165	24	60	42	136	61	87
7	165	25	61	43	153	62	113
8	100, 101, 102	26	119	44	125	63	63, 64
9	103	27	151	45	110	64	64
10	104	28	141	46	166	65	65
11	93	29	47	47	150	66	15
12	106	30	(¹)	48	157	67	115
13	105	31	128	49	160	68	111
14	107	32	134, 136	50	164	69	112
15	8, 9, 10	33	139	51	159	70	108
16	25, 31, 33, 34, 35,	34	50	52	161	71	110
	37, 38, 39, 40, 41	35	117	53	Page 75.	72	(²)
17	48	36	127	54	140		
18	52	37	138	55	166		

¹ Not tabulated.

² Data not available.

The list of crosses—containing the summaries and statements just mentioned—gives, in a very condensed form, clear and adequate evidence for two important conclusions which are treated at length in succeeding chapters. These conclusions are (1) that the hybrids which arise from crosses of forms more and more distantly related show less and less fertility, and (2) that the sex of the hybrids which arise from crosses of forms more and more distantly related becomes more and more predominantly male.

It is also well to note in the list the frequency of hermaphroditism and the entire absence of gonads in hybrids from "wide" crosses. The author has little noted this matter; but the autopsies of some hundreds of his hybrids, made by the editor, and the complete summaries of all of the records demonstrate, in the opinion of the editor, that hermaphrodites are far more frequent in the offspring from wide crosses and from hybrid parents than from intra-specific and pure-bred matings.

In order to facilitate the consultation of the complete breeding record, in connection with an examination of the data for sex and fertility, as summarized in this chapter, a list of table references (p. 12) has been prepared. The numbers in the left-hand columns of that list correspond to the number of the cross (in the pre-

Individual matings testing absolutely infertile.

Description.	Width of cross.	No. of eggs tested.	Reference to original MSS.
Orientalis (19) × gyrans (1903).....	Fam.	16	F 22
Orientalis (1) × gyrans (1).....	Fam.	12	C 7-6
Orientalis × domestica (black).....	Fam.	15	F 22
Domestica-orientalis (F2) × domestica.....		6	F 26
Domestica-orientalis (F2) × livia.....		4	F 26
Domestica-orientalis (A1) × gyrans (T1).....		2	F 24
Admista-orientalis × gyrans.....		12	G 18
Domestica-orientalis × domestica.....		2-4	A 13
Orientalis × risoria-orientalis.....		5	F 14
Risoria-orientalis-orientalis.....		3	F 18
Orientalis-risoria (6) × alba-risoria × turtur (D7).....		2	F 18
Alba-orientalis (3) × alba-orientalis (5).....		14	F 9
Ocyphaps × risoria.....	Subfam.	16	C 7-46
Risoria × Ocyphaps.....	Subfam.	20	X 14
Risoria (M1) × Ocyphaps.....	Subfam.	10	X 9
Risoria (M1) × Ectopistes (III B) (do not know No. eggs).....	Subfam.	4	BB 5
Risoria (M1) × gyrans (T5).....	Fam.	?	X 11
Risoria (M1) × gyrans (T5)..... (This ♂ (M1), however, only partially fert. w. an alba × ris. hyb.)	Fam.	10	X 11
Risoria × gyrans (T5).....	Fam.	8	X 9
Risoria (GF2) × gyrans (1).....	Fam.	2	C 7-6
Risoria (2) × carolinensis.....	Subfam.	6	DD 8
Risoria × chinensis.....	Gen.	10	DD 13
Risoria (A) × chinensis (T.c.).....	Gen.	6	X 4
Chinensis × risoria.....	Gen.	2	DD 13
Domestica × palumbus.....	Sp.	22	F 29, A 13
Tumbler (T6) × maculosa (? trace of dev. in 1).....	Sp.	3	G 21
Turbata × risoria (F)—(1, 1 to 2 da. emb.).....	Fam.	13	C 7-46
Illyrica (Arl) × alba (W2).....	Fam.	6	C 7-28
Illyrica (Arl) × risoria-alba.....	Fam.	4	C 7-28
Tabellaria (Hom. 2) × risoria (L1).....	Fam.	13	C 7-4
♂ Risoria-alba × G. humeralis.....	Subfam.	13	C 7-12
Risoria-alba (ZD 201) × gyrans.....	Fam.	25	G 19
Domestica-risoria × alba (W).....		25	C 7-39
Risoria-douraca × Geotrygon.....	Subfam.	2	XNS
Carolinensis × alba.....	Subfam.	30	C 7-7
Carolinensis-risoria (C1) × risoria (F of 1899).....		4	C 7-47
Carolinensis × alba-risoria (XW 2 (C2).....	Subfam.	4	C 7-47
Carolinensis × alba-ris × ris-alba (N2-O).....	Subfam.	3	C 7-47
Carol-ris × alb-ris × ris-alb × alb-ris × ris-alba.....		4	C 7-47
Migratorius-risoria × alba-ris × ris-alba.....		2	SH 32-13
Domestica-risoria × archangel-tumbler.....		13	C 7-46
Alba-ris × ris-alba × carolinensis (2, E1).....	Subfam.	10	C 7-23
Alba-ris × ris-alba × domes-ris × gyrans (T4).....		7	C 7-47
Alba-risoria × risoria-alba × carolinensis.....	Subfam.	4	X 7
Alba-risoria × risoria-alba × carolinensis.....	Subfam.	7	C 7-21
Alba-ris × ris-alba × tigrina × ris-alba.....		6	DD 17

CHAPTER III.

FERTILITY AND THE SEXES.¹

"Fertility varies much in individuals of the same species, at different ages and at different stages of the season.

"The sexes in normal fertility are about even.

"The sexes in lowered fertility show a predominance of males.

"The sexes in much lowered fertility are males only.

"The sexes in the lowest fertility do not appear—no offspring.

"Lowered fertilization shows various degrees, in which development makes a feeble beginning, then halts after a few days. It may run up to within a few hours or days of hatching and then halt. The developmental processes may also show different degrees of energy fullness, weakness, irregularities, etc., after hatching.

"When fertility is presumably not up to normal, certain colors—such as white—may be exclusively female. White rings are of both sexes—but in hybrids between white rings and Japanese turtles the white offspring are all females."² (R 16)

Whitman's later studies—all of which were in evidence at the time the above was written (1910)—clearly show that fertility does not bear a single, simple relation to sex, but a sort of *double* relation. Indeed, the double relation which fertility, or at least which "fertility" and "developmental energy," bear to sex would at first sight seem to be contradictory.

Nowhere has Whitman written connectedly or fully on this seeming contradiction, nor has he written very extensively upon the multitude of facts and illustrations bearing upon the second relation which he discovered that fertility bears to sex. This rather meager exposition of these important results was in keeping with a studied policy not to allow himself to write, or definitely to fix opinions, until he had studied the facts from all possible angles of approach. In the records of his last six or seven years of work, however, one finds very frequent allusions—a word or a phrase—to this second relation which he found that fertility bears to sex, and which at this time he undoubtedly considered as of equal or of even greater importance than the earlier discovered one. Briefly stated, this second result is that, in many crosses of very distinct species or of genera, fertility (developmental power) is shown to be *highest in the spring and lowest in the autumn; and that male offspring predominate in the season of highest fertility, while females³ largely predominate in the season of lowest fertility.*

But, we ask, how can this fail to contradict the first result—compactly stated above in the second paragraph under this section—which lists "much lowered fertility" as producing "only males"? It is necessary to treat this whole matter immediately and at some length.

¹ The editor has written this chapter; the author's statements are here placed in quotation marks.

² "Herbst (Arch. f. Entw. Mech. vol. 24, No. 2, 1907) thinks that resemblance to father and mother is settled by the size of the copulating nuclei. If female nucleus is at highest level, the resemblance is towards the maternal side. It is sheer *superiority in energy*."

³ Color and longevity in the offspring are also, to an appreciable extent, affected in the seasonal shift of fertility and sex; these characters, however, may to advantage be considered elsewhere.—EDITOR.

At the outset we would note that the second paragraph, referred to above, is not an amplification or explanation of the first paragraph; but each paragraph tells of a different and main fact that had been learned concerning fertility. The two succeeding paragraphs contain statements true alike for, and associated with, both of the two main facts on fertility.

The tabular statement of the second paragraph is of course merely a condensation of a lengthy consideration already given in the introductory chapter concerning the fertility of crosses in pigeons. We herewith reproduce, for the sake of clearness and convenience, paragraphs covering the essential points:

"The infertility of crosses is not to be confounded with sterility; it stands rather for various degrees of specific incompatibility between the germ-cells of the cross-mated birds. We do not know what this incompatibility⁴ means, but it is certain that it is in no way accounted for by external causes, such as difficulties in copulation, or in the conjugation of the sperm and ovum. In many cases the development of the egg is carried far enough—to the formation of a blood-circle—to show that the sperm has entered the egg and fertilized it. The development may halt at this point, or earlier, or be carried on to any later stage, even to hatching. The young bird may die within a few hours, or live on, apparently doing well, for several days, a week, or more, and then drop off as if life were a time-fuse calculated to end at a definite moment.

"The term of development often lies within such definite limits that, once ascertained, we may know about what to expect in future trials with the same birds. *The length of the course to be run, although varying widely, is, on the average, cut shorter and shorter as the crosses range from close allies to more distantly related species.*"

Again: "The causes of infertility in crosses, or more correctly, the causes of fertility in lower and lower degrees as the divergence between the crossed species increases, have yet to be investigated. . . . A single species may be fertile with all, or most of its congeners, and, in lower degrees, with members of other genera and even of other families."

From his earlier work, then, the author learned that if pigeons most widely separated phylogenetically were mated, the fertility ("germ compatibility") there was lowest and that no offspring could be had. If forms somewhat less widely separated were chosen for matings, some germs were fertilizable, and in development these would almost or quite invariably produce males. Forms still less removed phylogenetically when crossed produced males predominantly; and so on until closely related forms are reached which are fully fertile, and which throw the sexes in approximately equal numbers. If, then, we allow birds to produce their "strongest germs" (no reproductive overwork), but progressively cut down the fertility of these *by choosing consorts more and more distantly related*, we thereby increase the chances of producing male offspring,⁵ as long as any offspring may be obtained. This is the gist of the earlier findings on the relationship of fertility and sex.

⁴One can perhaps profitably remind himself here of the situation involved in anaphylaxis, immunity, etc.—EDITOR.

J. Loeb (Arch. f. Entwickl'mech., Bd. 27, 1908) finds in the extremely wide crosses which he has made with lower forms that the products of parts of the foreign sperm finally act as a poison and cause the eggs to develop abnormally. O. Hertwig (Arch. f. Mikr. Anat., Bd. 82, 1913) further finds that such foreign or poisonous substances contained in the sperm may be neutralized or destroyed by prolonged treatment with radium. Godlewski (Arch. f. Entwickl'mech., Bd. XXXIII, 1911) has called attention to the analogy between these features of fertilization and certain aspects of immunity.—EDITOR.

⁵This holds true also for matings (some genera) from which every egg, or almost every egg produced, is fertilized and hatched.—EDITOR.

The second main fact on fertility ("germ strength") was developed from observations on the gradations which this function presents in different individuals of the same species, and which it may undergo in one and the same individual. Age, season, and the rate at which eggs are produced were all found to affect the heights or levels of fertility in pigeons. And the two sexes were here also found to be associated with fertility ("germ strength")—maleness with greater fertility (strength), femaleness with weaker fertility. It is this aspect of fertility that is referred to in the first quoted paragraph.

From some of those crosses in which fertility was "lowered" and the resulting offspring were "predominantly male" it was noted that the "occasional" females more often appeared *at or near the end of the season*. Moreover, such results were more frequently obtained in such of the matings as had produced a greater number of eggs than usual, as a result of the prompt removal of these eggs as soon as laid to other birds for incubation. In other words, *reproductive overwork, in such a series, tends towards the production of female offspring*. Lateness of season and crowded reproduction seemed each to play a part in the production of females from gametes otherwise producing only or mostly male offspring. These earlier indications were confirmed by later work. The body of evidence bearing on these points must, of course, be presented later, but we note here the fact that often—in a mating of the above sort in which the dominance of sex is shifted during the season from maleness to femaleness, under "crowded reproduction"—some embryos are produced very late in the season not strong enough to break through the shell; and still later, embryos are produced of fewer and fewer or of no days of development. These weak germs, at this season, may proceed from a pair whose earlier eggs—of spring and early summer—produced hatchable, vigorous, and long-lived birds which were mostly or only males. The *loss of fertility during the season*⁶ involves, then, a progressive weakening of the germs themselves after starting from a given—reduced—level of fertility (germ compatibility) produced by selecting consorts of distant phylogenetic relationship. There are, then, two distinct kinds of things that have been called "lowered fertility"; and the two means of obtaining a low (or a high) fertility very differently affect the production of sex.

A few paragraphs—immediately following the first four given at the beginning of this chapter—bear upon this matter of "weakened germs." They were written beneath the caption: "Strength in Parents Tends to Produce Male Offspring."

"There is from pigeon crosses a preponderance of males from first eggs, and of females from second eggs. The first egg of the clutch may be supposed to have the advantage, as its needs are provided first, and the second egg, which is always the last of a clutch, has not quite equal chances, for it does not have first chance.⁷

"I think the first eggs of the season are certainly stronger than those coming late in the season. Elsewhere the early birds are the ones most highly prized by breeders. In poultry

⁶ This loss of fertility ("germ strength") is to be observed in the eggs of much "overworked" females, whether they are mated to one of their own or of a very different species.—EDITOR.

⁷ Whitman writes (W 9) that "The male and female have potentially the same characters. Usually the female lags behind, but sometimes the male lags," and cites Darwin's *Descent of Man*, Vol. II, pp. 191-199, and Beddard's *Animal Coloration*. This subject is more fully treated in Volume I, Chaps. V-VII.

generally we expect to get the best results from the earlier birds hatched, and fewer failures occur in early settings than in later."⁸ (R 16).

With these several statements before us it is possible to approach more closely to an understanding of the author's whole view of fertility, and to see that the two lines of fact which he developed concerning it are consistent, though at a glance we seem to say, first, that "lowered fertility" tends to the production of males, and second that "lowered fertility" tends to produce females.

The facts are that so long as we operate upon the function of fertility *merely by a choice of consorts*—and this on a basis of close or distant phylogenetic relationship—then the more we reduce the fertility the higher the proportion of male offspring, and the series runs thus:

- (1) In normal fertility the sexes are about even.
- (2) In lowered fertility males predominate.
- (3) In much lowered fertility only males are produced.
- (4) From the lowest fertility no offspring develop.

If, however, we take a pair of birds from groups (2) or (3) of the above scheme (and this will usually mean doves from different genera or subfamilies) and further study and analyze the genetic possibilities of this pair, we find that over and above the fertility incident to such a mating *per se* this degree of fertility is influenced by season, age, health, and reproductive work. And, associated with "lateness of season" and "reproductive overwork" there occurs an obvious decrease in fertility (developmental power) caused, not as in the preceding series, through relative "incompatibility of germs," *but by a progressive weakening of germs*; and the initial "lowered fertility" *plus this weakening of germs, may produce females*. Each sex predominates when its characteristic fertility level exists.

No. (3) of the above series if thus amplified and written in terms of this second series of facts would stand as follows:

Much lowered fertility ⁹ + strong germs = nearly all males.

Much lowered fertility + medium strong germs = sexes about equal.

Much lowered fertility + weaker germs = females.

Much lowered fertility + weakest germs = no development.

⁸ "De Vries holds that *species* are separated by *absolute* gaps, that can not be closed up. They arise by jumps or as sports. Were this the case, we ought to see sudden gaps in 'fertility.' I find that fertility is a thing of degrees, *i.e.*, it is at an optimum within the species, but it diminishes gradually—not by steps—as we pass from the crosses between species closely related to crosses of species wide apart. Examples of such a series are the following: White and blond ring; Japanese ring and blond ring; blond ring and Chinese ring; blond ring and European turtle; blond ring and Surate turtle; blond ring and homer. And similar to the last named, blond ring and *Ectopistes*; white or blond ring and mourning-dove; blond ring and white-wing; common pigeon and Japanese turtle." (These five last-named crosses are all of *family* or of *subfamily* rank.—EDITOR.)

"Again, fertilization within the species is of every degree, and results therefore in simple penetration of sperm which fails to make more than an early beginning of development or nothing at all, or it may give stages of change, etc., up to blood formation, and from this point it may go on and stop after forming an embryo, or at any point up to hatching; and when hatched, the fate is not yet settled; the bird may be deformed and still live; it may be too weak to develop further or go on and die at three, four, five, six, or more days. All along the line we see that development requires energy and stops or goes wrong for failure in this. Young birds often make failures. Doves reach the highest point at three to four years. . . . The energy of development and degree of fertility appear to be correlated."

⁹ Obtained by mating birds distantly related; "strength" is, in all probability, added by the act of crossing.—EDITOR.

Color, like sex, is to some extent involved in this flux of strength of germs. Dark and white, at any rate, are sometimes thus involved; dark color being the more closely associated with strong germs, whiteness more often associated with weak germs, though instances of sex-limited color inheritance were found which, apparently at least, do not at all conform to this rule.

A statement may be made at this point concerning the author's interpretation of this seasonal change of fertility, sex, and color. Neither of these did he ever refer to as a "shifting of dominance," partly because he had assured himself of the incompleteness or inadequacy of Mendelian and representative particle conceptions of heredity,¹⁰ and therefore preferred, in such instances, not to use that terminology; partly also because his data inclined him to believe that in this seasonal change from males to females there is a real reversal or change in the sex-potency of the individual germs, due to or in accord with the weakening effects which (as fertility) he had repeatedly observed and partially analyzed; that is to say, a given pair of germ-cells which, if matured and united under one set of conditions (strength) will produce a male, can be made under another set of conditions (weakness) to give rise to a female.

The author of course thoroughly appreciated the possibility that selective fertilization, differential maturation, and selective mortality of ova in the ovary might conceivably here be operative, and that one or all of these would be appealed to by others, who had not seen all that he had seen, to account for this "shifting of dominance" or apparent sex-reversal. Nor did he permit himself a definite or final decision of the question of sex-reversal.

The evidences within the "shifting-of-dominance" series itself, which to him most strongly suggested real sex-reversal as the correct interpretation of the series, were: (1) the demonstration that there is a *gradual* diminution in developmental power of the germs of these same series from spring to autumn—sometimes a nearly continuous line along which are strung males, males and females, females, female embryos, and embryos of fewer and fewer days of development, to a point of very little or no development; (2) the demonstration that stronger and longer-lived birds arise from the earlier, stronger germs than from the later and latest ones. This latter result he has himself noted only in cross-bred series. The attention of the reader will often be drawn to this matter in the case of the wider crosses; moreover, since all the records have been summarized and the longevity data put in place by the editor, it has become apparent that to an extent the same fact holds true in the overworked pure-bred series as well as in the cross-bred series.

The following quotation from Lumley¹¹ (p. 35) will show that among fancy or domestic pigeons some of the "weakening" effects of overwork at egg-laying have been recognized by breeders of these forms:

"Fancy pigeons generally show an inclination to mate together some time in the month of February; but much depends upon the temperature, as in very severe weather they will sometimes show no signs of doing so until March, whilst if it be mild some birds, if allowed, would go to nest in January. This, however, the owner should in all cases prevent, by keeping the sexes separate, for several reasons. In the first place, though it is possible the

¹⁰ See Chapter XIV.

¹¹ Fulton's Book of Pigeons. London, 1895. The quotation given was indicated by means of a page reference by the author; it was not copied into the author's manuscript.—EDITOR.

young ones may be reared, and if the weather keeps mild throughout they will in that case make wonderfully strong early birds, still the chances are many against it. But still more though the young be reared, the result is likely to be the ruin of the constitution of the hen; for if she is what is called a free breeder, or lays her eggs fast, before the season is over she becomes so weak as in many cases to become ruptured, and in other cases barren, when she is of course valueless. The cause of this is not only the excessive laying—indeed a young and rank hen will often lay, like a fowl, whether she be mated or not—but the cock-bird continually driving her to nest and teasing her while in her weak state, which causes her weakness of course to increase, until the ovary gives way, and she becomes what is called “down behind.” A most singular fact is that we have often noticed the mate of such a hen to become similarly affected, in which case he is commonly said to be “gizzard-fallen”; but having dissected many birds in such a condition, we can state positively that the gizzard has nothing to do with it, but that the part affected is a portion of the intestines. We never knew a cock breed in such a condition; and though we have occasionally known a hen do so, the progeny of such birds could not be expected to have any but a weakly constitution. In any case, it is much better to get even only three or four pairs of eggs in a season, hatched at a time when they are likely to become strong and healthy birds and preserve the constitution of the parents also for next season. We have known some persons, by what is called “pumping” a hen, or breeding from her as long as possible, obtain eight or nine pairs of eggs from her in one season; but we have seldom known more than half reared, and often some of these would have crooked breast-bones, which is a great fault as well as a sign of weakness. And as to the hen herself, she is, as already stated, if not entirely ruined, seriously debilitated for life, so that none of her after progeny will be as vigorous as they ought to be.”

The data of this volume will show that the various species of wild pigeons and many of their hybrids can be overworked, or “pumped,” very much more extensively than is indicated above for the domestic pigeon breeds, and without such evident permanent *somatic* injury to the parents. A more complete analysis of the relation of season and the order of the egg of the clutch (in *wild* species) to this weakening, and the relation of all of these points to fertility and to sex is, however, treated for the first time in these pages.¹²

It may be emphasized that Professor Whitman was by no means inclined to dogmatize as to the interpretation of this sex series. The editor had ample opportunity to know the author's mind on this subject better than on most others, since during the winter of 1908-9 it was decided that the present editor should join in an attempt to learn more of the germs which might beforehand be known to be of male-producing or of female-producing value. The chemical investigations then outlined and several other investigations in line with the original purpose have been, and are now being, continuously carried on and will be published by the editor probably not long after the present volume leaves the press. We would add here that if the data which the author had before him, and now found in these pages, leaves doubt that a real *reversal* of sex was effected in the cases herein described, such doubt would seem to be wholly excluded by the results of the four years of additional study of this material by the editor, the studies having been

¹² It seems scarcely necessary to state that Whitman's generalizations upon infertility, longevity, etc., were made after an accounting of such external or incidental things as poor incubation, poor feeding, poor care, greater winter mortality (of *all* birds—the early and the late-hatched—which of itself would tend to make the birds of late season shorter-lived on the average than those hatched earlier) among pigeons, etc. The very full data of the tabulated breeding records amply demonstrate this.—EDITOR.

made specially to test this point and to learn something of the nature and hereditary basis of sex.

"The fertility of the crosses extends to the hybrids, but generally not with the full strength and constancy shown in the parent birds. In this respect, the generic (ring-turtle) hybrids fall more or less below the specific hybrids, and in both classes the degrees in fertility descend with the degrees in relationship between the parent species.¹³ The hybrids are more often males than females.¹⁴

"Germs are as variable as the soma itself. A recent proof of this I find in the young of a pair of homers (Dec.-Jan. 1908-9). One of the young has juvenal wing-bars like the stock-dove (weakened), the other has feathers almost white and the bars are obsolete—only traces." (K 12)

It is clear then that the central feature of the author's extensive hybridization studies—the subject dealt with in this volume—is the demonstration of germs of several grades of genetic non-equivalence and these strung upon a line; concerning which line he has obtained some definite and illuminating information leading to the conclusion that germs subjected to certain procedures are forced to one or another level of hereditary and developmental power.

In the following summary the author has presented a situation respecting fertility which he had found to be largely typical of many crosses of pigeons, namely, lower fertility in the *very first egg* or eggs of the season; then a period of high fertility, followed by a prolonged period of much reduced fertility or of absolute infertility in late summer or autumn:

A male mourning-dove raised in 1897 was mated during the season of 1898 with a ring-dove, but hatched nothing. The same bird was mated in April 1899 with another ring-dove. This pair had egg and young as follows:

A 1. Apr. 23, 1899; no development.	A 1. May 29, 1900; no development. ¹⁵
A 2. Apr. 25, 1899; no development.	A 2. May 31, 1900; no development.
B 1. May 30; hatched.	♂B 1. June 16; hatched.
B 2. June 1; hatched.	? B 2. June 18; hatched (no gonad).
♂C 1. June 30; hatched.	C 1. July 3; poor incubation.
♂C 2. July 2; hatched.	C 2. July 5; poor incubation.
♂D1. Aug. 1; hatched.	♂D1. July 12; hatched.
♂D2. Aug. 3; hatched.	D 2. July 14; hatched.
E 1. Sept. 8; no development.	E 1. Aug. 18; no development.
E 2. Sept. 10; no development.	E 2. Aug. 20; hatched.
F 1. About Oct. 1; no development.	F 1. Oct. 6; no development.
F 2. About Oct. 3; no development.	F 2. Oct. 8; no development.
G 1. Oct. 31; no development.	G 1. Jan. ? 1901; no development.
G 2. Nov. 2; no development.	G 2. Jan. ? 1901; no development.

Here three successive pairs of eggs were hatched between June 14 and August 18. The male continued to sit faithfully until the first week in November. He began to sit

¹³ "In Plants, according to Swingle and Webber (1897, p. 388), *widely different families* never yield hybrids. *Distinct genera* usually yield no hybrids. *Distinct species* of same genus often yield hybrids. Cultivated races, or natural varieties, of same species generally yield hybrids." (A 1)

¹⁴ "See Buffon, vol. 3, p. 3, supplement. Meckel refers to this in vol. 1, p. 312. Davenport concludes: Inheritance in Poultry, Publication of the Carnegie Institution of Washington No. 52, 1906, p. 100 that "prepotency is as truly important in inheritance as dominance." This is certainly true in pigeons. The same author finds also that "the proportion of the two sexes in hybrids is normal. Among pigeon hybrids this does not hold." (K 12)

¹⁵ This second list is added by the editor from the author's data, for comparison. This record is complete in table 100. Only males are known from crosses of the mourning-dove and the ring-dove (a cross of subfamily rank).

in November, but soon lost interest. This male and female, although remarkably successful in fertilizing and hatching during the normal season, failed after August, *i.e.*, at the end of regular season for the mourning-dove. (R 11)

Fertility and the sexes, everywhere in the earlier chapters of this volume, occupy the center of interest, but these are interwoven with the following several topics, the data upon which must be presented as fully as is possible:

- (1) Decreased fertility associated with lateness of season.
- (2) Weak germs associated with lateness of season.
- (3) Femininity associated with lateness of season.
- (4) White color associated with lateness of season.
- (5) Association of extreme youth, old age, inbreeding and overwork, with weak germs, female sex, and white color.
- (6) The relative strength and sex tendencies of the two eggs of the pigeon's clutch.¹⁶
- (7) The nature of fertility, weak germs, sex, albinism.

Practically, it would prove difficult, however, and involve much repetition, to attempt a separation of the data at hand with a view to presentation under these several headings. Moreover, the nature of the data, having to do with associated or correlated phenomena, renders such a separate treatment nearly or quite impossible. We feel obliged, therefore, to present *seriatim* the large number of breeding records which have a common bearing on these questions, and to accompany these with some discussion when necessary. Some items can nevertheless be specially emphasized in the consideration of particular records; and part of the data can be reserved for later treatment (in later chapters) of one or two of the above-mentioned subjects. As elsewhere intimated, the results have been obtained by a close attention to the nature and product of *individual* birds, and indeed of *individual* eggs.¹⁷ It is therefore quite essential to an exposition of the results, or to the formation of a judgment upon them by others, that they be presented in a form—with a detail and completeness—hitherto unknown in the publications of studies in genetics.

¹⁶ The author has considered this point particularly in crosses, and in wild species of pigeons. See close of Chapter XIII for a fuller statement. —EDITOR.

¹⁷ Before undertaking an examination of the breeding records of the large numbers of groups of crosses it may be well to note that "infertility" proceeding from accidental or temporary sources such as poor care, cold, etc., have been very carefully recorded by the author, and such cases are fully designated in the tabulations of this volume. There are cases, too, in which eggs were laid by females after their mates ceased to copulate. These and similar circumstances were evidently closely followed, and the conclusions which were drawn upon the subject of fertility are most certainly not affected by the "infertility" traceable to such causes.—EDITOR.

CHAPTER IV.

JAPANESE TURTLE-DOVES CROSSED WITH A DISTANTLY RELATED AND WITH A CLOSELY RELATED SPECIES.¹

The present chapter and the three following ones deal with the breeding and crossing of the Japanese or Oriental turtle-dove. The data included bear upon several different subjects, but chiefly with "degree of fertility" in association with longevity and sex. The relation between "weak germs" and season, crowded reproduction, inbreeding, and "mutations" are touched upon at many points. All of these topics are met with in the present chapter, where the first purpose is to record the data for the fertility, sex-ratio, and longevity of the offspring of the three species concerned when individuals are mated (1) to their own kind, (2) to a related species, and (3) to an unrelated species.

Different individuals of the species *Turtur orientalis*, under even normal or usual conditions, bestow very different possibilities of length of life upon their offspring. When mated with their own species the strongest pairs of Japanese turtles should produce offspring with a life-term of perhaps 3 to 15 years or more. Data on this point will be found toward the conclusion of the chapter. When crosses are made, the "width of the cross" very measurably affects (in the widest crosses) the number of eggs that will hatch, and also the length of life and the sex of the resulting offspring. By "width of cross" is meant the degree of phylogenetic separation of the species used.² When a species closely related to *T. orientalis* is used as the other member of the cross, more of the eggs will hatch, the young will live longer, and the sex-ratio in the offspring will be more nearly that normal to a mating of two *T. orientalis* than when a species distantly related to *orientalis* forms the other member of the cross. The species most closely related to *T. orientalis* is the European turtle-dove (*Turtur turtur*), and the most widely separated species with which the Japanese turtle has been mated is the domestic pigeon. *Columba admista*, *C. affinis dom.*, *C. tabellaria*, and *C. gyras* were the common pigeons most used. The external characteristics of the Japanese turtle-dove are well shown in pl. 1. The common pigeons are too well known to require special illustration or description here; one is shown with its hybrid mate in pl. 3, and several are figured in Volume I. There is no connected body of data to be presented on the length of life of the common pigeon, but it is generally known that they easily attain 5 to 15 years.

COMMON PIGEON × JAPANESE TURTLE-DOVE.

Five female Japanese turtles were tested with 7 male common pigeons. They formed 8 different matings which will be individually described; but the tables which accompany these pages are relied upon to supply many points of information and to permit a closer view of the essential facts.

From the first mating (*admista* × *orientalis*, 1) 16 eggs were tested (table 1). Four eggs showed no development; 3 produced embryos unable to complete develop-

¹ The textual statement of this chapter has been written by the editor; all of the tabulated breeding records used here are those of the author.

² The affinities and phylogeny of the pigeons are treated in Volume I of these works. A partial sketch of the classification has been given at the close of Chapter II of this volume.

ment, and one of these was strikingly abnormal, having rudimentary legs with only two front toes, and with abnormal nostril; 9 young were hatched. One lived long—nearly 10 years; 4 died in less than 2 weeks.

The second and third matings (*tabellaria* × *orientalis*, 12 and 31) supply 23 tests of value (table 2), though incubation was not perfect in 5 or 6 of these; 4 did not begin development (2 possibly from poor incubation); 7 developed, but failed to hatch (most of them from poor incubation); 12 hatched, 1 lived nearly 5 years, 2 others of uncertain life-term but probably of 2 to 4 years, while 9 died in less than 3 weeks after hatching; 1 of these latter birds had deformed legs.

A fourth pair (*tabellaria* × *orientalis*, 29) of more mature birds that were worked less vigorously at egg-production gave perceptibly better results (table 3). The term of life of their offspring is noticeably increased. It is nevertheless quite clear that the features common to a cross of widely separated species are present. Tests were made on 19 eggs; 2 did not begin development, 2 others developed but were deserted, embryos were produced in 4, 11 hatched. One of the offspring lived more than 6 years, while 4 others lived from 2 to 3 years; 4 died within 3 weeks of hatching, and 2 of these were deformed.

Pair 5 (*affinis* × *orientalis*, 2) yielded still better results. The female of this pair was remarkable for the high degree of fertility of her eggs in other matings also, and for having lived in captivity for more than 15 years. She was paired with three different common pigeons, and was later mated for a term of 7 years with a male of her own species. In the twelfth and thirteenth years of her captivity, and when mated to her son, she produced "mutant" offspring, noted at the end of this chapter and treated more fully in Chapter V. Of her fertility while mated with the first of the three common pigeons under consideration we may note that all of the 6 eggs tested were hatched (table 4), and that the life-term of the offspring was probably longer than has been observed in the preceding families. Here, too, where fertility and longevity are less narrowly limited, a female (?)—deformed, and having a very rudimentary ovary—is found among the offspring. Still another of this family—the clutch-mate³ of the deformed female (?)—also had deformed legs and died two weeks after hatching. One of the hybrids from this cross is represented in pl. 35.

A male homer (*C. tabellaria*, 1) which will later be noted as a remarkably fertile bird (fertile with *St. risoria*) was given to the above *T. orientalis* female in the autumn immediately after the production of the last-mentioned series of fertile eggs. This pair (6) was then made to produce eggs as rapidly as possible. This gave the result best made clear by reference to table 4. The extreme end of the season yielded 5 eggs incapable of beginning development. Only 4 eggs hatched from 11 adequate tests; 1 of the young was deformed, and 1 full-term embryo was also probably deformed. From pair 7 (*C. affinis*? × *orientalis* 2) only 4 eggs were obtained; these immediately followed the "overwork" period of the preceding pair. Two were tested, though imperfectly; one produced an embryo, the other did not.

Pair 8 was formed two years later by mating this same female with an immature male (*C. admista*? R 1). The pair was overworked. They supplied 21 tests with

³ The term "clutch" is applied to the two eggs laid at one nesting period. The second egg is laid 40 to 48 hours after the first. Particulars for the various species are given in Volume III.



Adult female Japanese turtle-dove, *Turtur orientalis*. $\times 0.8$. Toda del. The feathers have broad centers of black color; their edges are of lighter color, gray, bronze, or reddish.

only 5 hatched; 14 showed no development; 2 formed embryos. One of the young was alive at 2 years of age, and another escaped when 8 months old. The other 3 lived less than a month.

The sex of 16 offspring of this series of matings, involving *T. orientalis* in a cross of family rank, is known. Of these 14 were known to be males; possibly 2 were females, one having a very rudimentary ovary, the other copulated as a female (a very inadequate test of sex) and almost certainly produced no eggs, though it lived nearly 5 years.

The data on the fertility of the reciprocal cross are not very extensive, but indicate complete infertility. Three such pairs of ♂ *orientalis* × ♀ common pigeon gave 43 tests, all of which proved absolutely infertile. These wholly infertile tests are further analyzed as follows:

Orientalis (19) × gyrans (1903).....	Fam.....	16	(F 22)
Orientalis (1) × gyrans (1).....	Fam.....	12	(C 7/6)
Orientalis × domestica (black).....	Fam.....	(15?)	(F 22)

FERTILITY TESTS OF HYBRIDS OF COMMON PIGEON × JAPANESE TURTLE-DOVE.

Three males from pairs 1, 5, and 8 described above were tested for fertility. Only one of these (A 1)—the one that probably lived longest and arose from the most fertile original cross (pair 5)—proved fertile. This male was mated back to a common pigeon;⁴ the restrictions upon the fertility and upon the life-term of offspring of this cross (pair 9) are notable and are presented fully in table 6.

An examination of the record makes it clear that though some development proceeds from some of the fertilizations of this pair, it is, in a very high percentage of cases, quite narrowly limited. There is a high percentage of eggs (28 of 59) showing no development whatever; 13 produced embryos only; 17 hatched, 1 or 2 of these requiring to be helped from the shell; 6 of those hatched died within 2 to 27 days. The length of life of 5 young is not known, but probably only 4 lived to maturity. This very bad record may have been somewhat influenced by the element of inbreeding, since the hybrid was mated to a probable half-sister; but that this is by no means the chief adverse factor is indicated by the fact that the short period during which an unrelated female (*C. affinis*) was used there was still less fertility—no trace of development in any of 5 eggs. A factor of more importance, perhaps, is that of overwork. This hybrid and his consorts were worked more rapidly, during much of this mating period, than is favorable for the production of strong germs. Nevertheless the main features of this mating record is clearly to be referred to the hybrid nature of the sire, as will become clear later when the fertility of hybrids from closely related species shall have been examined. The failure of germs to begin development, the limitations placed upon the development and upon the life-term of the offspring, all become more and more pronounced as the hybrids are derived from more distantly related species.

From this cross more of the second eggs of the clutch showed the less development of the pair—11 to 6. One female of this cross was of white color (color of her paternal and (?) maternal grandfather); two females had the color of the father, and one resembled the mother. One male was white, one was chequered, and one was black.

⁴ A female *C. livia* was also used during a short period; this pair proved entirely infertile.

The other matings of hybrids of this series tested absolutely infertile, and are as follows:

Domestica-orientalis (F 2) \times domestica.....	6 (F 26)
Domestica-orientalis (A 1) \times gyrans (T 1).....	2 (F 24)
Admista-orientalis (F 2) \times gyrans.....	12 (G 18)

JAPANESE TURTLES CROSSED WITH EUROPEAN TURTLE-DOVES.

Four pairs of the two closely related species, *T. orientalis* and *T. turtur*, were mated and gave a result in striking contrast to that obtained by crossing *orientalis* with common pigeons. Reference may be made to pl. 2 in order to see how much *T. turtur* has in common with *T. orientalis*. In these crosses it will be found that practically all eggs hatch; that abnormal embryos or birds are not present; that the life-term of the offspring is longer than in the cross with common pigeons; that the resulting hybrids are fertile; and that males do not notably outnumber the females.

Pair 1 was composed of a male *turtur* and a female *orientalis*. 20 of their eggs were tested and 20 young were hatched; 5 of these lived more than 3 years and 1 is still alive at more than 10 years. The shortest terms of life are 51 and 59 days; these are, at the same time, the eggs laid latest in the year and at the end of a period of overwork at egg-production. Likewise the shortest lived bird of the preceding year was from the last egg of that year (see table 7).

Four years later the female of pair 1 was mated with another male of the European species. These birds, called pair 1a, produced 20 eggs, 12 of which were tested; of these 10 hatched, but the "last clutch" of the season failed even to begin development. Coincident with this diminution of fertility, as compared with other pairs, there is likewise a marked shortening of the life-term of the birds that were hatched; 1 or possibly 2 offspring lived 1 year and 5 months; 5 died at less than 5 months. From this mating, too, females predominate—5 females to 1 male.

Pairs 2 and 3, recorded in tables 8 and 9, supply data for the reciprocal cross. 6 eggs from pair 2 were tested; all hatched, and all lived longer than 2 years. When this same male was later mated to a *turtur* \times *orientalis* hybrid (9) several eggs failed to hatch, and the several young lived from 1 week to 7 months (table 10). From pair 3 the 4 eggs obtained gave rise to 4 young, all with a life-term of 2 to 3 years.

The sex-ratio in these crosses is quite different from that observed in the common \times Japanese matings. From the *turtur* \times *orientalis* cross the sex is known of 21 birds—7 males and 14 females. This excess of females occurs principally during periods of forced or crowded reproduction. From the reciprocal cross 4 males and 2 females were obtained. All of the hybrids—male and female from the cross made in both directions—are fertile. The data establishing this fact will now be presented.

TURTUR HYBRIDS CROSSED INTER SE AND WITH PARENT SPECIES.

In the first cross of *T. turtur* and *T. orientalis* these species seem to be fully fertile. There is, perhaps, some evidence from the probably reduced longevity of the offspring which would warrant a qualification of the term "fully fertile." When the fertility of the hybrids themselves is tested there is then no question as to the reduction of fertilizing and developmental powers—or compatibilities—of their germs; and this diminution of fertility then exhibits itself not only in a still further limitation upon the life-term of the F_2 generation, but in the evident failure of many germs to begin development and in the early or late abortion of many promising beginnings of development.



- A. Adult European turtle-dove, *Turtur turtur*. $\times 0.6$. Toda del. Dark centers of feathers narrower and less prominent than in the Japanese turtle-dove (plate 1); the red edging is more prominent in *turtur*.
- B. Juvenal male Japanese turtle-dove, *T. orientalis* (56). From egg of 8-15-05; age 6 weeks. Hayashi del. Nov. 1905. $\times 0.5$. The juvenal color presents feathers with dark centers and light edges, as does the adult (plate 1), but the differentiation and the boundaries are here less distinct. The neck-mark shows only as rows of feathers.

This group of hybrids showed also ill-adjusted reproductive *instincts*. The records of 5 pairs of these hybrids, or of a hybrid mated to a parent form, are given herewith. In all of these there is a history, usually quite persistent, of "deserted" eggs or young. This desertion of the nest is more frequently met with in the hybrids than in either of the parent species. Soft-shelled eggs are noted in 2 of the 5 matings; a dwarf egg in 1. The meaning of these reproductive abnormalities is not clear, but their incidence in individuals or generations whose germ-cells are also "ill-adjusted" merits further consideration.⁵

A brother and sister from the ♂ *turtur* × ♀ *orientalis* cross were mated when a little less than 1 year old. This pair (5) produced 14 eggs during their first (immature) year. Table 11 shows the consistently poor results: 1 egg gave no embryo, 1 a weak embryo, 5 produced embryos but the eggs were deserted and were not given a complete test, 6 hatched, 1 lived but 10 days, while the remaining 5 all died between 1 month and 2½ months after hatching. During the following year the pair produced 11 eggs, of which 8 were tested; 2 failed to produce embryos and 6 were hatched; all except 1 lived 2½ to 5 months; the exception lived 22 months. The pair evidently produced stronger germs when 2 years old than when in their first year. The sex of 9 of the young is known—3 males and 6 females.

A sister to the birds of pair 5 just described was mated to a male of the *orientalis* × *turtur* cross. This pair (6) was more mature when mated, but persistent desertion of eggs (see table 12) permitted only 4 adequate tests of the 16 eggs produced during two years; 2 of these (and also 2 deserted ones) produced embryos, and 2 hatched. One of the latter was a male which lived 4½ months.

A brother to the male of pair 6 was tested when 1 year old with a pure Japanese female. From 8 tests (11 eggs) 3 young were hatched with life-terms of 3 days, 2 months, and 16 months. In their second, more mature, year they again yielded 11 eggs; of these 8 hatched and 3 were quite infertile. Three died early, 4 lived 3 to 8 months, and 1 is still alive at nearly 8 years (table 13). Two males and 3 females are known from the eggs of the second year. The better result from the more mature birds is obvious.

A male *orientalis* × *turtur* hybrid was mated when 1 year old to a ¾ *orientalis*—¼ *turtur* hybrid hatched from the preceding pair (6). The result is a demonstration of still lower fertility and a still further restriction upon the life-term of offspring than pertains to either of the earlier crosses from which the two parents were produced. Table 14 indicates 11 tested eggs; of these 4 are known to have been absolutely infertile; 1 gave an embryo only. 6 eggs hatched, but the term of life of probably all of them was between 5 days and 2½ months (table 14). None of the hybrids from the *orientalis*-*turtur* crosses tested infertile.

The following cross is of unusual interest. A hybrid from two races of common pigeons was mated with a female *turtur* × *orientalis* hybrid. Here the two individuals finally crossed are widely separated forms, but in addition each parent is itself a hybrid from two closely related species or varieties (common pigeons). Attention may first be given to the fact that color in the offspring is here a sex-limited character, the males being dark, the females light in color. There is one apparent exception for each sex. The female that was not of light color was "dark

⁵ For treatment of several related topics see "The Reproductive Cycle," Vol. III of these works.

with patches of pure white," and was so remarkable as to be separately described later. The male listed as "to be of light color" died at 6 days, and it seems possible that this early prognosis of color was wrong. At any rate, the author later records (R 16) this cross as exhibiting sex-limited inheritance. It may be pointed out that this type of heredity in a cross between species of different *families* has not hitherto been reported. The two parents are shown in pl. 3; a darker male hybrid and one of the light females from this pair are also shown in the same plate.

The data (fully given in table 15) show that from this cross all of the 18 eggs of the first year were hatched—a very remarkable result in the light of what has been seen of the results of pure individuals of *Columba* crossed with pure individuals of *Turtur*. We meet here, too, the further interesting fact that though all of the eggs are capable of hatching, the term of life of the young is *limited to quite the same period* as were the offspring of pure *Columba* \times pure *Turtur* (see tables 1, 2 and 3). This period for 11 young of the first year was 1 to 22 days after hatching, and the 6 hatchlings of the following year all fell within this same period. The life-term of birds from eggs laid in May of the first year forms a notable exception; 6 birds from the 6 eggs of this period produced birds that lived from several months to more than 3 years, and 1 male from this group is still alive at nearly 7 years. Immediately following this group, 1 young lived 64 days, and then the term of life again fell to a few days.

The abnormalities met with in those earlier (pure *Columba* \times pure *Turtur*) crosses, moreover, promptly reappear in this record. There are three or probably four groups of such abnormalities. The first of these is the already familiar abnormal legs, these being short and directed backward in one individual. This bird came from the eleventh egg of the season, July 1; its clutch-mate sister of July 3 was also abnormal in that she bore only 10 rectrices (tail feathers), instead of the normal 12. This latter deficiency is shown in 3 other *sisters*, or in 4 of a total of 5 females which lived long enough to permit an examination of this portion of the plumage; and it is not without interest and significance to note that the reduction of these rectrices is quantitatively expressed, in order, by the numbers: 11, 10, 10, 9. And that this series (9 represents primaries *not* rectrices) runs from early in the season to later in the season, and thus corresponds also to the sliding scale of longevity already noted. Moreover, all of the *males* and the *earliest female* of this series have the normal number—12 tail feathers.

The third abnormality or group of abnormalities was borne by a bird hatched from the sixteenth egg of the season (August 22) and the second of the clutch. It had much "white" scattered over the body (see footnote to table 15), and there "was nothing in the ancestry to explain these flecks and patches of white." As a further expression of weakness this bird had only 9 primaries. It is probable that the second egg of the following clutch—the very last of the season—produced also a bird with abnormal plumage; its "down" was recorded as "almost whitish," but it died before anything further could be learned of it.

In several instances we shall again see the same thing that is evident here, namely, that deviations from the type present themselves most frequently in individuals hatched from "weakened" germs. Among the pigeons the factors producing these weakened germs are at least partially known, and a considerable part of the effort of this volume aims at the presentation of this information.

A



B



C



- A. Adult male owl-homer hybrid No. 2 (to the left). Adult female *Turtur turtur* \times *T. orientalis* hybrid No. 8 (to the right). $\times 0.3$.
- B. Hybrid male (C 2) from owl-homer hybrid \times *T. turtur* \times *T. orientalis* hybrid. Hatched May 3, 1908; photographed at 6 months. $\times 0.4$. Color gray-reddish on secondaries and long coverts. The medium coverts have marks of a bar. This is one of the larger hybrids.
- C. Hybrid female (E 1) from owl \times homer hybrid \times *T. turtur* \times *T. orientalis* hybrid; May 28, 1908. Photographed at 5½ months. $\times 0.35$. Color light-gray; central marks of feathers weak. Chequering present, but weak, on the long coverts.

Enough is known of the history, nature, and causation of these deviations or "mutations," some of which have been shown to "breed true," to enable one to predict that they will arise only or almost exclusively from such weakened germs.

FERTILITY AND LONGEVITY IN PURE-BRED JAPANESE TURTLE-DOVES.

It remains to indicate the normal percentage of fertile eggs produced by *T. orientalis* when pairs of individuals of this species are mated together, and further, to supply data upon the sex and longevity of the offspring of these matings for comparison with the very limited life-terms noted particularly in crosses of this species with a distantly related one.

The presentation of the data in a complete and tabulated form will, moreover, serve two other necessary objects. First, these tables assist, as do others of this book, in a demonstration of the relation that exists between season of hatching and of longevity of the offspring, and the further facts of *individual* differences in the capacity of parents, due to age, health, overwork, etc., to produce strong germs. In the second place, many of the young whose origin is given in these tables are later studied extensively as parents; the all-important features of the germinal foundations from which they grew can be shown adequately, owing to the associations just noted, only by means of such tabulations. This holds especially true of the "mutations" which appear at the extreme end of the record; and these "mutations" become the subject-matter of the succeeding chapter.

The one breeding record available for *T. turtur* is presented at this point. It much resembles the records for *orientalis* which are to follow. Table 16 shows that of 9 eggs tested, 8 were hatched; there is no definite record for the other one. The shortest life-term is 4 months, and one of the young was alive and breeding at 51 months. The two longest-lived birds were from the second clutch of the season; the egg that probably failed to hatch, and the bird of shortest life-term, were from the last (fifth) clutch of the year, laid July 26-28; 3 males and 4 females are known from this family.

Especially complete records are available for the results of 4 of 5 matings in pure Japanese turtle-doves.⁶ From pair 1 there were 21 tests, and, as is shown in table 17, all were hatched; 2 eggs, the first pair of the second season, were poorly incubated, but both developed to hatching. Here again the young of longest life-term arose from early (not the "very earliest") eggs of the season; the birds from the last eggs died youngest. Neither the question of age nor of possible relationship of the two birds of pair 1 can be definitely answered; they were imported together and their short-lived offspring may be inbreds. That the term of life of their offspring is too short—is indeed a "time fuse" set at about 3 months—is apparent. The death of both the parents early in 1906 and the lameness of the sire indicate weakness and possibly old age as contributory causes of their weakened germs. 4 males and 4 females are known from this family.

The data for pair 2 are very incomplete (table 18). Eggs were obtained only from an unfavorable season of the year. The parents were imported together and may have been related. They were overworked. 6 of their 11 eggs were deserted, for 1 there is no record; probably 3 eggs produced embryos and 1 showed no development. Both parents died soon after these eggs were produced.

⁶ Matings involving inbreeding of Japanese turtles are specially considered in the next chapter.

The parents of pair 3 were certainly not closely related, probably not related at all. They were both long-lived, but the female of this pair died a few months after the close of the season recorded in table 18A. They were not overworked. 6 of their 7 eggs hatched; 1 showed no development. The long-lived offspring were from May and June. The first egg and the last egg hatched the shortest-lived young.

Pairs 4 and 5 were most adequately tested and are the matings of greatest interest. The same female was used in the two matings; the members of pair 4 were probably not related; in pair 5 the female of the former pair was mated with her son. This record covers a period of 8 years. A juvenal male offspring (56) from pair 4, from the third year of this mating, is shown in pl. 2. The most important feature of these two matings is the appearance of three "mutations" at the close of the period, when the dam was at least 12 to 14 years old and when inbred to her son. The distribution of sex, longevity, and fertility, as displayed in table 19, is also of much interest.

In a closer examination of these two matings we note:

(1) Two sexes arose from the same clutch in 14 cases; in 10 of these the first egg produced a male, in 4 cases the first hatched a female.

(2) In 9 of these same cases the bird from the first egg lived longer than its clutch-mate from the second egg; in 4 cases less long; in 1 this is unknown.

(3) Of the 9 long-lived birds, 7 are males, 2 are females; of the 4 short-lived birds from the first egg 2 are females.

(4) Two females hatched from individual clutches in 4 cases; in two of these the bird from the first of the clutch lived much the longer.

(5) Of 7 such pairs of males the birds from the first egg lived longer in 5 cases. Birds from the first egg therefore lived longer than their mates in 16 such cases, died earlier in 8, at the same time in 2; the data are insufficient in 5 cases.

(6) A tabulated summary of the longevity of offspring, fertility, and the sex-ratio corresponding to each of the 7 years this female (of pairs 4 and 5) was mated, is as follows:

Average age	(14)	yg. of 1903=42+	mo.; ⁷	eggs unhatched=0	(in 19);	8♂; 5♀	
"	"	(12)	" " 1904=23+	"	"	"	=1 (in 16); 7♂; 6♀
"	"	(9)	" " 1905=18+	"	"	"	=2? (in 14); 4♂; 4♀
"	"	(8)	" " 1906=24+	"	"	"	=1 (in 12); 5♂; 4♀
"	"	(8)	" " 1907=18+	"	"	"	=? (in 14); 4♂; 4♀
Inactive 1908; mated <i>with son</i> , 1909 10.							
Average age	(2)	yg. of 1909=	8½	mo.;	eggs unhatched=1	(in 4); 1♂; 2♀	} 3 "mutations"
"	"	(6)	" " 1910=26+	"	"	"	
						=2 (in 8); 2♂; 3♀	

The longest term of life (1903) coincides with the highest proportion of males and with the highest fertility; the very shortest term of life (1909) coincides with the maximum of infertility, the highest proportion of females, with very old age of the mother, and to inbreeding with an immature son.

(7) White color "mutations" occur only at the end of the series, when the female parent is quite old (12 to 14 years in captivity), when fertility is lowest, when the proportion of females is highest, when longevity is reduced, and when inbred to her son.

The question of the nature and breeding value of the color "mutations" which appear in this record, and of the effect of inbreeding of Japanese turtles, on the fertility, sex, longevity, and the general topic on "strength of germs," will be considered in the next chapter.

⁷ In these series which include one or more birds alive at the time of writing, a plus sign (+) is added to the average age (in months).

TABLE 1.

Pair 1.

♂ *C. admista* (Z); 1894 or 1895 (?); escaped¹ 12 22 00; 6 ± yr.
 ♀ *T. orientalis* (1); imported 1897 (?); dead¹ 3 1 98; ? yr.

A. 8/4/97.....	relieved; ² abnormal legs . . .	dead 8 24 97	20 da ³
A 1. 9/6.....	hatched.....	dead (trip), 9 29 97	24 da
A 2. 9/8.....	hatched; light gray.....	dead 10 6 97	28 da
B 1. 10/6; no development.			
B 2. 10/8; developed 14 to 15 day embryo.			
C 2. 10/23; developed to hatching; failed; legs rudimentary, etc. ⁴			
C 2. 10/25; hatched right leg imperfect; killed.			
♂D 1. 11/5.....	hatched (like sire + red) . . .	dead 12 7 97.	32 da
D 2. 11/7; no development.			
E 1. 11/16; no development.			
E 2. 11/18.....	hatched.....	dead (care?) 12 17 97.	30 da
F 1. 12/18; no development.			
♂F 2. 12/20.....	hatched; infertile ⁵	alive 1/29/00	2 ± yr.
G 1. 1/12/98.....	hatched.....	dead (care?) 1 29 98	17 da
G 2. 1/14/98; nearly fully developed; failed.			
♂H 1. 2/1.....	hatched.....	dead 11, 15/07.....	9 yr. 10 mo.
H 2. 2/3; disturbed.			(F 29)

¹ In this, and in most of the numerous succeeding tables of this volume, the age and length of life of both parents and offspring are included in the tables. A bird used as a parent has the date of hatching placed immediately after its name and number; the date of its death follows, and the length of its life-term is placed to the extreme right of the table. The date of the death of the various offspring of the record and the length of their life-terms are arranged in columns beneath the equivalent data for the parents.—EDITOR.

² That is, egg was opened by the observer at or after the time to hatch.—EDITOR.

³ The age is usually reckoned from time the egg is laid; this bird marked "20 da." lived but 4 days after hatching.—ED.

⁴ "Only two front toes, and the right nostril also abnormal."

⁵ "Head speckled with white, elsewhere much white."

TABLE 2.

Pair 2.

♂ *C. tabellaria* (1903); killed 9/15/05; 2 + yr.

♀ *T. orientalis* (12); 5/26/03; dead 6/17/05; 2 yr., 21 da.

A 1. 4/10/04.....	hatched.....	dead 5/6/04 (bad food?).....	26 da
A 2. 4/12/04.....	hatched.....	dead 5/7/04 (bad food?).....	25 da
♂B 1. 4/19.....	1.....	hatched, no other record.....	(?1 month to 4 years ?)
B 2. 4/21; failed to hatch, possibly neglect or cold.			
C 1. 4/30; no development, possibly cold.		D 1. 5/9; developed, not hatched; possibly injured.	
C 2. 5/2; no development, possibly cold.		D 2. 5/11; developed, not hatched; possibly injured.	
E 1. 5/28.....	2.....	hatched, no other record.	
E 2. 5/30; hatched late, failed to compete for food; killed 6/25/04.			
F 1. 6/12; no development.			
♀F 2. 6/14.....	3.....	dead 5/29/09.....	4 yrs., 11 mo., 12 da.
G 1. 7/14.....	hatched.....	dead 8/4/04 (food?).....	21 da.
G 2. 7/16.....	hatched, deformed legs; 8/3/04 (killed).....		18 ± da.
H 1. 9/2.....	hatched.....	dead 10/2/04 (food?).....	30 da.
H 2. 9/4.....	hatched.....	dead 10/9/04 "no clear reason".....	35 da.
I 1. 3/9/05; deserted.		K 1. 4/14; deserted.	
I 2. 3/11; deserted.		K 2. 4/16; deserted.	
J 1. 3/24.....	one developed, neglected.	L 1. 4/23; developed, deserted.	
J 2. 3/26.....		L 2. 4 25; developed, deserted.	
M 1. 5/16.....	one, probably M 1, hatched "strong bird" died 6 16/05		30 da.
M 2. 5/18.....	other egg did not hatch.		

Pair 3.

♀ *T. orientalis* (31); 7/9/04; 3/21/06; given to above ♂ June 19, 1905.

N 1. 8/15/05.....	hatched.....	dead 9 24 05	1 mo., 9 da.
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(F 22, A 10)

TABLE 3.

Pair 4.

♂ *C. tabellaria* (2); (stray bird, 1903?); no record of death.♀ *T. orientalis* (29); ancestry unknown; (not "29, young of 1 × 1"); date of death not known.

A 1.	5/29/05.	hatched.	died very young.	(?) 20 da.
A 2.	5/31/05;	no development.		
B 1.	6/13.	hatched	died at 7-14 days.	deformed, asymmetry. (?) 26 da.
B 2.	6/15.	hatched	died at 7-14 days.	(?) 26 da.
♂ C 1.	7/14.	4 R.	dead 2/1/11-11/3/14.	6+ yrs.
♂ C 2.	7/16.	4 L.	dead 4/18/08.	2 yr., 9 mo.
D 1.	8/15.	5.	dead 11/11/07.	2 yrs. 3 mo.
D 2.	8/17;	no development.		
E 1.	10/10.	6.	no later record; probably short-lived	? 2 mo. to 1 yr.
E 2.	10 12;	nearly hatched.		
F 1.	3/2/06;	deserted.	G 1.	3/24; thin-shelled, broken.
F 2.	3/4/06;	deserted.	G 2.	3/26; thin-shelled, broken.
H 1.	4/4.	7.	dead 2/5/08.	1 yr., 10 mo.
H 2.	4/6;	developed a little.		
I.	5/3;	developed, deserted.		
J 1.	5/26;	no record; almost certainly not hatched.		
J 2.	5/28.	8.	7/29/06.	2 mo.
K 1.	6/16;	failed to hatch.		
K 2.	6/18;	failed to hatch.		

(Birds idle during this period at Woods Hole.)

♂ L 1.	9/16.	9.	12/27/09.	3 yr., 3½ mo.
L 2.	9/18;	stunted legs.	10/11/06.	1 mo. (F 22)

TABLE 4.

Pair 5.

♂ *C. affinis* ¹ *domestica* (3); about 3/1/97; killed 9/26/97.♀ *T. orientalis* (2); imported 5/24/97; dead 11/17/12; 15+ yrs.

♂ A 1.	8/18/97.	hatched	one, called A 1, fertile; accident 4/30/02	56+ mo.
♂ A 2.	8/20/97.	hatched	one died 2/28/98	6 mo., 10 da.
♀ B 1.	8/27.	killed Jan. 1899	(legs deformed; ovary very rudimentary)	17+ mo.
B 2.	8/29.	hatched, legs deformed.	dead 9/26/97.	29 da.
C 1.	9/6;	hatched, starved.		D. 9/17/97; some development, broken.
C 2.	9/8;	hatched, starved.		

(See pl. 35 for the appearance of these hybrids.)

Pair 6.

♂ *C. tabellaria* (1) "At least two years old when obtained 2/2/97"; put here 10/17/97; removed 1/16/98; killed 11/2/02.

A 1.	10/17/97;	no development; incubation bad.		
A 2.	10/19/97;	no development; incubation bad.		
B 1.	11/9;	hatched; no later record.		
B 2.	11/11;	pricked shell, failed; probably an abnormal embryo.		
♂ C 1.	11/21.	hatched.	escaped 5/25/98.	7+ mo.
C 2.	11/23.	hatched, deformed legs.	dead 12/10/97.	17 da.
D 1.	12/4;	no development.		
♀ D 2.	12/6.	hatched; copulated 1898, built nests, but no eggs (apparently functioned as a ♀ when mated with sire).		
E 1.	12/16;	no development.		
E 2.	12 18;	no development.		
F 1.	12/30;	no development.		
F 2.	1/1/98;	no development.		
G 1.	1/8;	broken.		
G 2.	1/10;	no development.		

Pair 7.

♂ Common dove (2); age unknown, given 1/18/98.

A 1.	1/23/98;	thin shell, broken.		
A 2.	1/25/98;	thin shell, broken.		
B 1.	2/1	incubation imperfect; one egg developed but did not hatch. ²		
B 2.	2/3			(F 20, A 14)

¹ White fantail in the ancestry of this bird.² "Female No. 2 deserted all eggs given to replace clutches C' to G inclusive. Since the male nested faithfully it may be that these latter eggs did not have adequate opportunity to be fertilized." No further record of any matings, or eggs, of this bird (♀ 2) until 1900.—EDITOR.

TABLE 5.

Pair 8.

♂ Common pigeon (R 1) (gray w. dark bars); 8/12/99-7/15/02; 25 mo. (admista?)
 ♀ *T. orientalis* (2); imported 5/24/97; 11/7/12; 15 + yrs.

A 1. 3/29/00; no development.	C 1. 4/19; failed to hatch.
A 2. 3/31/00; hatched; died at one week.	C 2. 4/21; thin shell, broken.
B. 4/8; no development.	D. 5/2; no development.
E 1. 5/27; no development.	
E 2. 5/29; dark.	7/2/00. 1 mo., 3 ds.
F 1. 6/15; no development.	
♂ F 2. 6/17; hatched, infertile; alive.	5/20/02. 23 mo
G 1. 7/10; no development.	J 1. 5/20/01; no development.
G 2. 7/12; no development.	J 2. 5/22/01; no development.
H 1. 8/3; no development.	K 1. 6/15; no development.
H 2. 8/5; no development.	K 2. 6/17; no development.
I 1. 10/5; no development. ¹	L 1. 7/6; 8 to 10 day embryo.
♂ I 2. 10/7; hatched; "died young."	♂ L 2. 7/8; hatched; escaped 2/28/02. (G 4)

¹ Old birds separated from Sept. 1900 till May 15, 1901.

² In 1902 female *T. orientalis* (2) refused to mate with male *T. orientalis* (2).

TABLE 6.

Pair 9.

♂ *C. affinis* dom. × orient. (A 1); 8/19/97; accident 4/30/02; 56+ mo.

♀ Common pigeon (black).

The father of the bird here used as sire was partly white fantail.

The sire of this female is also the sire of her mate (A 1); i.e., these two birds probably half brother and sister. This female had laid 8 other eggs during the season before the following:

♀ C 1. 8/6/99; hatched; white.	G 1. 11/10; some development.
C 2. 8/8/99; no development.	G 2. 11/12; no development or slightest trace development.
D 1. 8/23; opened prematurely; live embryo.	H 1. 12/25; dead 1/18/00; "could not learn sex; well cared for."
D 2. 8/25; no development.	H 2. 12/27; no development.
E 1. 9/7; developed about 7 days.	
♂ E 2. 9/9; like <i>C. livia</i> : ¹ "fell dead suddenly" 4/14/01.	
F 1. 10/23; no development.	
F 2. 10/25; no development.	
I 1. 1/29/00; hatched; black.	R 1. 8/16; no development.
I 2. 1/31/00; chequered; trace red.	♂ R 2. 8/18; hatched, white; accident, 5/24/01, "a fine bird and probably fertile."
J 1. 3/7; some development.	S 1. 9/30; hatched; dead at 9 days (exposure?)
J 2. 3/9; no development.	S 2. 10/1; hatched; black, dead 12/20/00.
K 1. 3/30; dead 17 day embryo.	Copulation prevented 2 to 4 days before laying T 1 and T 2.
K 2. 4/1; no development.	T 1. 9/30 no development.
L 1. 4/12; some development.	T 2. 10/2; no development.
L 2. 4/14; no development.	
M 1. 4/30; dead 17 day embryo.	♂ U 1. 10/23; hatched; dead at 27 days (overfeeding?).
M 2. 5/2; helped from shell; complexion of sire; dead at 2 days.	U 2. 10/25; hatched; color leaden gray, like <i>C. uva</i> .
N 1. 6/1; no development.	V 1. 11/27; no development.
N 2. 6/3; some development.	V 2. 11/29; "developed fully; why it did not hatch I am unable to say. I opened it two days after it was due and found the bird dead but fully ready to hatch, the yolk having been almost wholly taken up. The sire now given to a chequered rock-dove that has not been mated for two years (since she came from England)." (F 26)
♂ O 1. 6/18; hatched; dead 7/21/00. ²	This mating is given in the next part of this table.
♂ O 2. 6/20; hatched; dead 9/1/00 (canker); "testicle very small."	
♀ P 1. 7/20; hatched; "color of sire;" dead 11/8/00; green discharge.	
P 2. 7/22; no development.	
Q 1. 8/3; hatched; dead at 6 days.	
Q 2. 8/5; 7 to 10 day embryo.	

¹ "Color of this bird, when adult, is a chequered ground gray, with spots black, closely like *C. livia* but plainly shading towards the condition of spots in the male grandparent. Cooing like that of common pigeon, but not so loud. Delivery and quality of voice were quite like the common pigeon. . . . Too, the bird showed in its attitudes and behavior some slight and hard-to-describe differences. The testes were enormous in size, 6-8 inches long by 5-16 inch in shortest diameter."

² "O 1 died July 21, age two weeks; short and somewhat irregular breathing noticed 2 or 3 days before death; bird was large and apparently healthy; do not know what the trouble was; perhaps some organic weakness of its hybrid constitution."

TABLE 6 (continued).

♂ *Affinis dom.* × *orient.* *hyb.* (A 1) (con.); killed 4.30 '02.♀ *C. affinis* (chequered); here till 1 22 01. (This ♀ suddenly unable to fly after laying egg B 1)

A 1. 12/31/00; no development.

A 2. 1 2 01; no development.

B 1. 1/18/01; thin shell.

B 2. 1/20 01; thin shell.

C 1. 2/19; no development.

C 2. 2/21; no development.

D. 4/1; no record.

♀ Common pigeon (black) reunited with this ♂ (see record for 1900, above) 4/10/01.

W 1. 4/14; no development.

W 2. 4/15; no development.

X 1. 5 1; 7 to 10 day embryo.

♂ X 2. 5 3; matured; "black like mother."

Y 1. 6/1; no development.

Y 2. 6/3; no development.

Z 1. 7 1; developed several days.

Z 2. 7/3; no development.

AA 1. 7/27; no development.

♀ AA 2. 7/29; dead 3/24/03; blackish.³

BB 1. 9/12/02; thin shell.

BB 2. 9/14/02; no development.

CC 1. 1/14 03; no development.

CC 2. 1/16/03; no development.

DD 1. 2/17; no development.

DD 2. 2/19; no development.

EE 1. 3/15; 12 to 14 day embryo.

EE 2. 3/17; two-thirds size first egg; prob. no development.

FF 1. 4/20; prob. no development.

FF 2. 4/22; prob. no development.

(F 26, A 13)

³ "This female had a very rudimentary ovary."

TABLE 7.

Pair 1.

♂ *T. turtur* (19); 7/1/1903; 9/22/05; 2 yr. 2 mo. 21 da.♀ *T. orientalis* (11); 5/12/03; 12/?/10; 7 yr. 7 mo. 16 da.

A 1. 5/1/04; broken.

A 2. 5/3/04; broken.

♀ B 1. 5/11.....1.....cold.....5/9/05.....1 yr.

♀ B 2. 5/13.....2.....3/31/07.....2 yr. 10 mo. 18 da.

♀ C 1. 5/25.....3.....5/23/05.....1 yr.

C 2. 5/27.....accident.....6/12/04.

♂ D 1. 6/4.....4.....2/27/08.....3 yr. 8 mo. 8 da.

♂ D 2. 6/6.....5.....alive.....8/1/14.....10+ yr.

E 1. 6/21.....lice-killed.....7/20/04.

E 2. 6/23.....lice-killed.....7/19/04.

♀ F 1. 7/25.....6.....10/10/07.....3 yr. 2 mo. 15 da.

♂ F 2. 7/27.....7.....cold.....4/25/05.....9 mo.

♀ G 1. 4/2/05.....8.....(see pl. 3).....5/13/10.....5 yr. 1 mo. 11 da.

♀ G 2. 4/4/05.....9.....11/18/07.....2 yr. 7 mo. 14 da.

H 1. 4/11; broken.

H 2. 4/13?; broken.

♀ I 1. 4/19.....10.....6/25/08.....3 yr. 2 mo. 6 da.

I 2. 4/21; broken.

J 1. 4/29.....11.....8/4/05.....3 mo. 6 da.

♀ J 2. 5/1.....12.....4/5/06.....11 mo. 6 da.

K 1. 5/19; deserted.

K 2. 5/21; deserted.

L 1. 6/6.....13.....killed.....6/27/05.

L 2. 6/8; no record.

♂ M 1. 6/21.....14.....1/25/06.....7 mo.

♂ M 2. 6/23.....15.....4/14/07.....1 yr. 9 mo. 21 da.

♂ N 1. 7/29.....16.....9/20/05.....1 mo. 21 da.

♀ N 2. 7/31.....17.....9/26/05.....1 mo. 29 da. (F 8, A 10)

TABLE 7A.

Pair 1a.

♂ *T. turtur* 1908 (?); exact date of birth and death unknown.♀ *T. orientalis* (11); (same ♀ as in pair 1 above).

♀ A 1. 6 20 09.....18.....9/5 09.....2 mo. 15 da.

♀ A 2. 6/22/09.....19.....9/2/09.....2 mo. 10 da.

♀ B 1. 7 10.....20.....10/28 09.....3 mo. 18 da.

B 2. 7 12.....21.....11/25/09.....4 mo. 13 da.

♀ C 1. 7/19.....22.....12/30/10.....1 yr. 5 mo. 11 da.

C 2. 7/21.....23; starved.

TABLE 7A (continued).

D 1. 4/5/10; no record. ¹	F 1. 5/24/10; no record.
D 2. 4/7/10; no record.	F 2. 5/26/10; no record.
E 1. 5/19; no record.	G 1. 6/8; no record.
E 2. 5/21; no record	G 2. 6/10; no record.
♂ H 1. 6/19.....24.....	2/10/11..... 7 mo. 21 da.
H 2. 6/21.....25.....hatched; no later record.	
♀ I 1. 7/28.....26.....	12/21/10..... 4 mo. 23 da
I 2. 7/30.....27.....died bet. 2/15/11-11/4/13.	
J 1. 9/8; no development. ²	
J 2. 9/10; no development.	(F 5)

¹ It seems probable, in view of the statement in note 2 below, and in the complete absence of record, that these eggs were not tested for fertility.—EDITOR.

² "Note that this failure to develop must be attributed to infertility of the male or female or both; and that fertility usually reaches a full halt in or by the end of August. The last fertile eggs were laid July 28 and 30, and the young were raised and so far doing well."

TABLE 8.

Pair 2.

♂ T. *orientalis* (10); 4/6/03; 10/10/07; 4 yr. 6 mo. 4 da.♀ T. *turtur* (2); 11/21/05; more than 2 yrs.

(Together 1904 without mating).

A 1. 4/9/05; deserted.	
A 2. 4/11/05; deserted.	
B 1. 4/20; no record.	D 1. 5/14; broken.
B 2. 4/22; no record.	D 2. 5/16; broken.
C 1. 5/1; killed.	E 1. 5/23; deserted.
C 2. 5/3; killed.	E 2. 5/25; deserted.
F 1. 6/10.....1.....certainly dead before 2/15/11.....	(?) 3+ yr.
♂ F 2. 6/12.....2.....	10/16/07..... 2 yr. 4 mo. 4 da.
G 1. 7/14.....3.....certainly dead before 2/15/11.....	(?) 3 yr.
G 2. 7/16.....4.....certainly dead before 2/15/11.....	(?) 3 yr.
♂ H 1. 8/26.....5.....	11/19/07..... 2 yr. 2 mo. 24 da.
♀ H 2. 8/28.....6.....	10/4/07..... 2 yr. 1 mo. 7 da.

TABLE 9.

Pair 3.

♂ T. *orientalis* (78); 4/19/07; 10/26/10; 3 yr. 6 mo. 7 da.♀ T. *turtur* (1); imported 1902-3; lived more than 6 yrs.

♂ A 1. 7/12/08.....7.....certainly more than 2½ yrs. and certainly less than 5½ yrs.	
A 2. 7/14/08.....8.....probably 1 or 2 years and certainly less than 2½ years.	
♀ B 1. 7/29.....9.....	8/13/10..... 2 yr. 1 mo. 15 da.
♂ B 2. 7/31.....10.....	6/30/11..... 2 yr. 11 mo. (F 11)

TABLE 10.

Pair 4.

♂ T. *orientalis* (10); 4/6/03; 10/10/07; 4 yr. 6 mo. 4 da.♀ T. *turtur* × T. *orient.* (9); 4/4/05-11/18/07; 2 yr. 7 mo. 14 da.

A 1. 5/1/06; developed, broken.	
♀ A 2. 5/3/06.....	11/4/06..... 6 mo. 1 da.
♂ B 1. 5/9.....gray (see description).....	8 15 06..... 3 mo. 6 da.
B 2. 5/11.....	6 10/06..... 29 da.
C 1. 5/18; soft shell, deserted.	D 1. 6/7; hatched, no record.
C 2. 5/20; soft shell, deserted.	D 2. 6/9; hatched, no record.
E 1. 3/15/07; deserted, hatched, not fed.	
E 2. 3/17/07; deserted, hatched, dead 4/9/07.....	23 da.
F 1. 3/23; deserted, hatched, thrown from nest 4/9/07.	
F 2. 3/25; deserted, hatched, not fed, died 4/8/07.	
♀ G 1. 4/2.....	11 7, 07..... 7 mo. 5 da.
G 2. 4/4; did not hatch.	
♂ H 1. 4/16.....	8 10, 07..... 3 mo. 24 da.
H 2. 4/18; apparently did not hatch.	
♂ I 1. 4/25.....	7/20, 07..... 2 mo. 25 da.
I 2. 4/27; deserted; no development (cold?)	
J 1. 5/11; deserted, no development.	
J 2. 5/13; deserted, no development.	(F 21)

TABLE 11.

Pair 5.

♂ Turtur × orient. (4); brother; 6/4/04-2/27/08; 3 yr. 8 mo. 7 da.

♀ Turtur × orient. (2); sister; 5/13/04-3/31/07; 2 yr. 10 mo. 18 da.

A 1. 4/1/05; some development, deserted.	C. 4/25; some development, deserted.
A 2. 4/3/05; some development, deserted.	
B. 4/16; removed.	D 1. 5/3; some development, deserted.
	D 2. 5/5; some development, deserted.
E 1. 5/27; deserted	one hatched, died 10 days later (sour crop); other some development, but not hatched.
E 2. 5/29; deserted	
F 1. 6/6.....	dead 9/12/05.....3 mo. 6 da.
♂ F 2. 6/8.....	dead 9/1/05.....2 mo. 23 da.
G 1. 7/8.....	dead 8/29/05.....1 mo. 21 da.
G 2. 7/10; did not develop.	
♀ H 1. 7/19.....	dead 9/5/05.....1 mo. 16 da.
♀ H 2. 7/21.....	dead 9/4/05.....1 mo. 13 da.
I 1. 4/4/06; no record.	
♀ I 2. 4/6/06.....	dead 9/26/06.....5 mo. 23 da.
J 1. 4/17; no record.	
J 2. 4/19; on ground broken.	
♂ K 1. 4/25.....	dead 9/20/06.....4 mo. 25 da.
K 2. 4/27; did not develop.	
♀ L 1. 5/4.....	9/28/06.....4 mo. 24 da.
L 2. 5/6; did not develop.	
♀ M. 6/2.....	dead 4/13/08.....22 mo. 11 da.
♀ N 1. 7/5.....	dead 10/3/06.....2 mo. 28 da.
♂ N 2. 7/7.....	dead 10/18/06.....3 mo. 11 da. (F 18)

TABLE 12.

Pair 6.

♂ Orient. × turtur (5); 8/26/05; 11/19/07; 2 yr. 2 mo. 24 da.

♀ Turtur × orient. (6); 7/25/04; 10/10/07; 3 yr. 3+ mo.

A 1. 5/23/06; deserted.	B 1. 6/5; deserted.	C 1. 6/20; some development; deserted.
A 2. 5/25/06; deserted.	B 2. 6/7; deserted.	C 2. 6/22; some development; deserted.
♂ D 1. 4/2/07.....	deserted.....	8/27/07.....4 mo. 25 da.
D 2. 4/4/07; developed, failed to hatch.		
E 1. 4/9; deserted.		G 1. 5/9 or 5/10; killed (young) by sire.
E 2. 4/11; deserted.		G 2. 5/11 or 5/12; failed.
F 1. 5/4; deserted.		H 1. 5/23; soft shell, broken.
F 2. 5/6; deserted.		H 2. 5/25; soft shell, broken. (F 18)

TABLE 13.

Pair 7.

♂ T. orient. × T. turtur (2); 6/12/05; 10/16/07; 2 yr. 4 mo. 4 da.

♀ T. orient. (11); 5/13/03; 12/?/10; 7 yr. 7+ mo.

A 1. 4/30/06; hatched; died at 2 or 3 days.	
A 2. 5/2/06; did not develop.	
B 1. 5/11; deserted.	D. 6/18/06; dwarf egg, 18.5 by 14.5 mm.
B 2. 5/13; deserted.	(this period at Woods Hole).
C 1. 5/23; no results.	E 1. 8/5; failed to hatch.
C 2. 5/25; no results.	E 2. 8/7; failed to hatch.
F 1. 9/10.....	1/13/08.....1 yr. 4 mo. 3 da.
F 2. 9/12.....	11/16/06.....2 mo. 4 da.
G 1. 3/30/07; deserted, hatched; no later record; probably died early.	
♀ G 2. 4/1/07.....	deserted; alive 8/1/14.....7+ yr.
♂ H 1. 4/13.....	deserted.....3 mo. 9 da.
H 2. 4/15.....	deserted.....5/5/07.....20 da.
I 1. 4/26; deserted, after a week; no development.	
I 2. 4/28; deserted, after a week; no development.	
♂ J 1. 5/13.....	8/13/07.....3 mo.
J 2. 5/15; no development.	
♀ K. 6/2.....	hatched.....2/8/08.....8 mo. 6 da.
♀ L 1. 7/2.....	hatched.....12/8/07.....5 mo. 6 da.
L 2. hatched, no later record; probably died early.	(F 21)

TABLE 14.

Pair 8.

♂ Orient. × turtur (10); 7/31/08; 6/30/11; 2 yr. 11 mo.

♀ Orient. × turtur (2) × orient. (11) (G 2); 4/1/07; alive 8/1/14; 7+ yr.

A 1. 4/22/09; deserted, no development.	B 1. 5/13; deserted, egg not examined.
A 2. 4/24/09; deserted, no development.	B 2. 5/15; deserted, egg not examined.
C 1. 5/25; developed, but failed to hatch.	
♂ C 2. 5/27.....	8 21 09..... 2 mo. 27 da.
D 1. 7/9; not fed; died early.	
D 2. 7/11; did not develop.	
♀ E 1. 7/25.....	8 18, 09..... 24 da.
E 2. 7/27; did not develop.	
F 1. 8/6..... canker.....	9 4 09..... 28 da.
F 2. 8/8..... canker.....	9 4 09..... 26 da.
G 1. No record.	
G 2. No record.	
H. 7/1/10; hatched; no later record.	(F 12)

TABLE 15.

Pair 9.

♂ Owl × homer hyb. (2); (July 1907); sire = silver, dam = thin black (see pl. 3).

♀ Turtur × orient. hyb. (8); (April 1905); 5/13, 10; color, interm. (see pl. 3).

♀ A 1. 4/12/08; hatched; light; dead at 10 days (canker).	
♂ A 2. 4/14/08; hatched; dark; dead at 10 days.	
B 1. 4/22; hatched; dead at 2 days.	
B 2. 4/24; hatched; dark; dead at 14 days.	
♂ C 1. 5/1..... hatched..... pale dark.....	alive 2/7/11..... 3+ yr.
♂ C 2. 5/3..... hatched..... dark.....	alive 1/1/15..... 7+ yr. (see pl. 3)
♂ D 1. 5/16..... hatched..... dusky.....	alive 11/17/08..... 6+ mo.
♀ D 2. 5/18..... hatched..... lighter.....	alive 11/17/08..... 6+ mo.
♀ E 1. 5/28..... hatched..... lighter (11 rectrices).....	died before 2/15/11..... (see pl. 3)
♀ E 2. 5/30..... hatched..... light (10 rectrices).....	died after 2/15/11..... 3+ yr.
♂ F 1. 7/1; hatched; (killed at 3 days); <i>short legs!</i> ; down was whitish yellow.	
♀ F 2. 7/3; hatched; pale blond-gray; dead at 64 days; <i>only 10 tail feathers.</i>	
♂ G 1. 7/19; hatched; to be dark; dead at 8 days.	
♂ G 2. 7/21; hatched; to be light; dead at 6 days.	
♂ H 1. 8/20; hatched; dark; dead at 22 days (exposure?).	
♀ H 2. 8/22; hatched; dark; ¹ dead at 19 days.	
♂ I 1. 9/3; hatched; down pale yellow; dead at 1 day (accident?).	
♂ I 2. 9/5; hatched; (exposed); "down almost whitish;" probably died very early.	

Birds separated 12/1/08 to 2/3/09.

J 1. 2/13/09; hatched; down pale yellow; dead at 3 days (overfed?).	
J 2. 2/15/09; hatched; darker than J 1; dead at 7 days (deserted).	
K 1. 3/12 one pricked shell; other some development	L 1. 3/28; hatched; not fed.
K 2. 3/14 (poor incubation).	L 2. 3/30; some development (poor incubation).
M 1. 4/7; did not develop.	
♀ M 2. 4/9; hatched; light; dead at 10 days.	
N 1. 5/6; no development.	
N 2. 5/8; hatched, overfed, dead at few days.	
O 1. 6/1; did not hatch.	
O 2. 6/3; hatched (overfed?), dead at few days.	
P 1. 7/20; no development.	
P 2. 7/22; hatched; ring-like down; killed at 9 days (had canker).	
Q. 8/19; no record.	(F 17, K 2)

¹ "The color of this bird is dark, about the same as H 1, but quite remarkable. It has 'white flecks' scattered quite thickly over the whole crown of the head, and also two white feathers in rump (otherwise dark grayish brown). Only 9 primaries. One under tail covert (middle) white; rest gray. Nothing in ancestry to account for it. The first case this season, and note that it hatched in *September*." (R 16)

TABLE 16.

♂ *T. turtur* (1); imported 3/?/09; date of death not known.♀ *T. turtur* (1); imported 3/?/09; date of death not known.

♂ A 1.	4/19/99.....	12/1/99.....	7 mo. 12 da.
A 2.	4/21/99; dwarf egg; 25 by 19 mm., no development, probably not a complete yolk.		
♀ B 1.	4/29.....	hatched.....	alive 7/23/03.....
B 2.	5/1.....	hatched.....	alive 7/1/01.....
♀ C 1.	5/28.....	12/14/99.....	6 mo. 17 da.
♂ C 2.	5/30.....	12/25/99.....	6 mo. 25 da.
♂ D 1.	6 26.....	11/26/99.....	5 mo.
♀ D 2.	6/28.....	12/29/99.....	6 mo. 1 da.
♀ E 1.	7/26.....	11/27/99.....	4 mo. 1 da.
E 2.	7/28; apparently did not hatch.		(C7/1)

TABLE 17.

Pair 1.

♂ *T. orientalis* (1); lame; imported April 1903; 4/22/06; 48+ mo.♀ *T. orientalis* (1); imported April 1903; 3/23/06; 48+ mo.

A 1.	4/21/04.....	26; dead 5/15/04 (food?).	
A 2.	4/23/04.....	27; dead 5/15/04 (food?).	
B 1.	5/20.....	26.....	dead 9/12/04.....
B 2.	5/22.....	27; dead 6/12/04 (food?).	3 mo. 22 da.
C 1.	6/16; egg broken.		
♂ C 2.	6/18.....	29.....	dead (fighting) 2/16/09.....
D 1.	7/12.....	32.....	dead 10/26/04.....
D 2.	7/14.....	33; lice-killed, early.	3 mo. 14 da.
♂ E 1.	8/3.....	33.....	dead 11/19/04.....
♂ E 2.	8/5.....	34.....	dead 11/29/04.....
♀ F 1.	8/26.....	37.....	dead 11/24/04.....
♀ F 2.	8/28.....	38.....	dead 12/9/04.....
G 1.	9/29; hatched; ¹ dead 10/?/04; "died within month."		
G 2.	10/1; hatched; dead 10/?/04; "died within month."		
H 1.	3/7/05; developed to hatching (incubation poor?).		
H 2.	3/9/05; developed to hatching (incubation poor?).		
K 1.	3/31.....	39.....	dead 8/16/05.....
K 2.	4/2; died very young.		4 mo. 15 da.
♀ L 1.	4/28.....	42.....	dead 7/18/05.....
L 2.	4/30.....	43.....	dead 8/6/05.....
M 1.	5/25.....	44.....	dead 8/19/05.....
M 2.	5/27.....	45.....	dead 7/30/05.....
♀ N 1.	7/1.....	51.....	dead 10/12/05.....
♂ N 2.	7/3.....	52.....	dead 9/24/05.....

(F 82)

¹ "Eggs of 1904 were usually deserted by the male."

TABLE 18.

Pair 2.

♂ *T. orientalis* (3); imported 5/6/03; 10/11/05; (age?); 2½+ yr.♀ *T. orientalis* (3); imported 5/6/03; 3/19/06; (age?); 3+ yr.

A 1.	1/25/05; some development.	C 1.	3/6; failed.	E 1.	4/14; deserted.
A 2.	1/27/05; no development.	C 2.	3/8; failed.	E 2.	4/16; deserted.
B 1.	2/19; deserted.	D 1.	3/26; deserted.	F.	4/25; no record.
B 2.	2/21; deserted.	D 2.	3/28; deserted.		

(F 28)

TABLE 18A.

Pair 3.

♂ *T. orientalis* (0); ("an old bird" in 1905); 10/28/08; 8+ yr. (probably 10 to 12 yr.)♀ *T. orientalis* (11); 5/13/03; 12/?/10; 7 yr. 7 mo.

A 1.	4/18/08.....	85; no later record; probably died early.	
A 2.	4/20/08; no development.		
B.	5/19.....	86.....	dead.....
♀ C 1.	6 23.....	88.....	dead.....
♀ C 2.	6/25.....	89.....	(killed, tuberculosis).....
D 1.	8/4.....		accident.....
♂ D 2.	8/6.....	90.....	dead.....

(F 28)

TABLE 19.

Pair 4.

♂ *T. orientalis* (2); imported early 1900; 3/12/08; 8+ yrs.♀ *T. orientalis* (2); imported early 1897; 11/17/12; 15+ yrs.

♂ A 1.	4/6/03.....10.....	dead (?).....	10/10/07.....	4 yr. 6 mo. 4 da.
A 2.	4/8/03.....	dead.....	4/24/03.....	16 da.
♀ B 1.	5/12\one.....11.....	disappeared.....	12/7/10.....	7 yr. 7+ mo.
B 2.	5/14\other broken.			
♀ C 1.	5/26.....12.....	dead.....	6/17/06.....	2 yr. 21 da.
♀ C 2.	5/28.....13.....	dead.....	3/4/06.....	2 yr. 9 mo. 6 da.
♂ D 1.	7/6.....14.....	dead.....	6/3/09.....	5 yr. 10 mo. 27 da.
♂ D 2.	7/8.....15.....	dead.....	8/4/05.....	2 yr. 26 da.
♂ E 1.	8/3.....16.....	dead.....	7/10/05.....	1 yr. 11 mo. 7 da.
♀ E 2.	8/5.....17.....	dead.....	11/28/08.....	5 yr. 3 mo. 17 da.
♂ F 1.	8/17.....18.....	dead.....	3/17/06.....	2 yr. 7+ mo. ¹
♂ F 2.	8/19.....19.....	dead.....	9/28/06.....	3 yr. 1 mo. 9 da.
G 1.	9/9; soft shell (after trip).			
♂ G 2.	9/11.....20.....	dead.....	11/24/04.....	1 yr. 2 mo. 13 da.
♀ H 1.	9/18.....21.....	dead.....	7/12/08.....	4 yr. 9 mo. 24+ da. ¹
♂ H 2.	9/20.....22.....	dead.....	6/19/06.....	2 yr. 9+ mo. ¹
J 1.	11/1; deserted; hatched; apparently died very young.			
J 2.	11/3; deserted; hatched; apparently died very young.			
K.	12/7; deserted (cold); unhatched.			
♀ L 1.	3/7/04.....23; dead, certainly lived longer than L 2.			
L 2.	3/9/04.....	not hatched, but fully developed.....		14 da.
♂ M 1.	4/8.....24.....	dead.....	11/1/06.....	2 yr. 6 mo. 23 da.
♂ M 2.	4/10.....25.....	dead.....	(?) before M 1.	
N 1.	5/11; dead; (cold) 5/31/04.			
N 2.	5/13; dead; (cold) 5/31/04.			
♂ O 1.	6/7.....27.....	dead.....	3/27/06.....	1 yr. 9 mo. 20 da.
♂ O 2.	6/9.....28.....	dead.....	10/5/04.....	3 mo. 25 da.
♀ P 1.	7/7.....30.....	dead.....	3/7/06.....	1 yr. 8 mo.
♀ P 2.	7/9.....31.....	dead.....	3/21/06.....	1 yr. 8 mo. 12 da.
♂ Q 1.	8/13.....35.....	alive.....	8/1/14.....	10+ yr.
♀ Q 2.	8/15.....36.....	dead.....	11/8/04.....	2 mo. 23 da.
♀ R 1.	9/15.....36.....	dead.....	11/6/05.....	1 yr. 1 mo. 21 da.
♀ R 2.	9/17.....37.....	dead.....	12/26/04.....	3 mo. 9 da.
♂ S 1.	10/31.....37.....	dead.....	12/25/07.....	3 yr. 1 mo. 24 da.
♂ S 2.	11/2.....38.....	dead.....	7/30/05.....	9 mo. 3 da.

Winter of 1904-5 this pair kept without chance to nest.

T 1. 3/4/05\one hatched; no later record; one began
T 2. 3/6/05\ development.

U. 4/2; deserted.

V. 4/24; deserted.

♂ W 1.	4/28.....40.....	dead.....	5/1/13.....	8 yr. 3 da.
♀ W 2.	4/30.....41.....	dead.....	8/11/05.....	3 mo. 11 da.
♂ X 1.	6/1.....46.....	dead.....	9/18/05.....	3 mo. 17 da.
♂ X 2.	6/3.....47.....	dead.....	2/11/08.....	2 yr. 8 mo. 9 da.
♀ Y 1.	7/9.....48.....	dead.....	11/28/05.....	4 mo. 19 da.
♀ Y 2.	7/11.....49.....	dead.....	9/29/05.....	2 mo. 18 da.
♂ Z 1.	8/15.....56.....	alive.....	11/8/05 (see pl. 2).	
♂ Z 2.	8/17.....57.....	(killed?).....	4/18/07.....	1 yr. 8 mo. 1 da.
♀ AA 1.	9/29.....58.....	dead.....	12/20/05.....	2 mo. 21 da.
AA 2.	10/1.....	dead.....	11/7/05.....	1 mo. 15(?) da.

TABLE 19 (continued).

BB 1. 3/8/06; large embryo.			
BB 2. 3/10/06.....59.....hatched; probably lived a few days only.			
♂ CC 1.	3/25.....59.....	dead.....	8/20/09.....3 yr. 4 mo. 25 da.
♀ CC 2.	3/27.....60.....	dead.....	(?) before ? CC 1.
DD 1.	5/1.....61.....	dead.....	7/21/06.....2 mo. 20 da.
DD 2.	5/3.....63.....	dead.....	8/17/06.....3 mo. 14 da.
♂ EE 1.	6/6.....66.....	alive.....	7/?/07.....1+ yr.
♀ EE 2.	6/8.....67.....	dead.....	12/19/06.....6 mo. 11 da. ²
♀ FF 1.	7/15.....68.....	dead.....	certainly before 7/1/11.
♂ FF 2.	7/17.....69.....	alive.....	8/1/14.....8+ yr.
♂ GG 1.	9/5.....70.....	dead.....	12/20/07.....1 yr. 3 mo. 15 da.
♀ GG 2.	9/7.....71.....	dead.....	4/8/08.....1 yr. 7 mo. 3 da.
♂ HH 1.	2/25/07.....74.....	dead.....	10/21/07.....7 mo. 26 da.
♀ HH 2.	2/27/07.....75.....	dead.....	4/9/07.....1 mo. 12 da.
♂ II 1.	3/17.....76.....	stolen.....	8/12/12.....(5+ yr.)
II 2. 3/19.....77; dead early bad ? care ?			
♂ JJ 1.	4/19.....78.....	dead.....	10/26/10.....3 yr. 6 mo. 7 da.
♀ JJ 2.	4/21.....79.....	dead.....	5/19/08.....1 yr. 28 da.
KK 1. 5/27.....81.....dead; no record.			
KK 2. 5/29.....82.....dead; (trip) 6/?/07.			
LL 1. 7/7.....82; no data.			
♀ LL 2.	7/9.....83.....	dead.....	5/20/08.....10 mo. 11 da.
♀ MM 1.	9/5.....84.....	dead.....	2/8/08.....5 mo. 3 da.
♂ MM 2.	9/7.....85.....	dead.....	1/31/08.....4 mo. 24 da.
NN 1. 1/27/08; deserted eggs.			
NN 2. 1/29/08; deserted eggs.			

(F 28)

♂ *T. orientalis* (2) died 3/12/08.♀ *T. orientalis* (2) given another ♂; remained inactive during 1908.³

Pair 5.

♂ *T. orient.* (69); 7/17/06; alive 8/1/16; 8+ yr.; =son and dam.

♀ A 1.	8/15/09; one..95.....	whitened.....	"mutant".....	dead 10/14/09.....	2 mo. (see pl. 4)
A 2. 8/17/09; other egg produced nothing.					
♂ B 1.	9/6.....96; "dark, about normal";	dead before B 2 (?)			
♀ B 2.	9/8.....97.....	"dark, about normal".....	11/23/10.....	1 yr. 2 mo. 15 da.	
C 1. 4/2/10.....98.....whitened....."mutant".....dead 7/9/10.....3 mo. 7 da. (see pl. 6)					
C 2. 4/4/10; unhatched.					
♀ D 1.	6/4.....99.....	(normal color).....	alive 8/1/14.....	4+ yr.	
D 2. 6/6; unhatched.					
♀ E 1.	7/23.....104.....	(normal color).....	dead 1/28/11.....	6 mo. 5 da.	
♂ E 2.	7/25.....105.....	(about normal color).....	alive 8/1/14.....	4+ yr.	
♂ F 1.	9/7.....108.....	whitened!.....	"mutant".....	dead 3/8/13.....	2 yr. 6 mo. (see pl. 7)
♀ F 2.	9/9.....109.....	normal.....	dead 9/3/12.....	2 yr.	(F 28)

² Left eye blind.³ In 1911 and 1912 this female (No. 2) refused to mate with male white rings. After September 3, 1912, she was with a fairly mature male *T. orientalis* (452) but with no result. She died November 17, 1912.—EDITOR.

CHAPTER V.

MUTATION, FERTILITY, AND LONGEVITY IN INBRED JAPANESE TURTLE DOVES.¹

At the end of the preceding chapter the long and remarkable breeding record of a female Japanese turtle-dove (*T. orientalis*, 2) was completely presented in the form of tables. That record, together with another closely associated with it, may now be fully discussed. This turtle-dove was kept in captivity for more than 15 years after her importation from Japan. In the twelfth and fifteenth years of this period she produced no eggs, and in the thirteenth and fourteenth years only 4 and 8 eggs respectively. During other years, including mating periods with common pigeons, from 12 to 20 eggs were laid per year. The few eggs of the thirteenth and fourteenth years were fertilized by a son; one-fourth of these eggs were infertile and 3 of the 9 eggs that hatched gave "mutant" young with whitened plumage. That this bird and her (earlier) mate, both taken wild in Japan, were quite pure *T. orientalis* is beyond question. They are both shown in pl. 6. Even a slight contamination with any species whatever, except possibly *T. turtur* of Europe, would have been easily detected in the birds themselves, while a quite uniform and very numerous progeny during many previous years strongly attest the purity of both parents. Finally, the "mutants" themselves are wholly unlike any other species of the genus *Turtur*, and equally unlike any related genera. These "mutants" are further considered and illustrated in the present chapter. Data dealing with the successful breeding of one of them is herewith given,² and the fertility and longevity records of inbred, non-inbred, and out-crossed relatives of these "mutants" are also presented.

THE JAPANESE TURTLE-DOVE MUTANTS OF 1909 AND 1910.

It is notable that the three "mutants" under consideration arose from a quite old female when mated with her son, and that two of the three striking variants arose from the *very first* egg of each year of the two years' duration of the mating. The third arose from the *last* clutch of eggs which this female ever laid, and this clutch was produced at the extreme end of the season, in September. These "mutants" bear, in order of their production, the numbers 95, 98, and 108.

The general appearance of these three is shown in a series of illustrations. No. 95 is figured in two plates: the live bird, together with plucked, expanded tail feathers (better to show the extent of the "whitening") in pl. 4; alongside a normal *T. orientalis* (94) of similar age in pl. 4; with its second growth of tail feathers, and expanded at the time of its death in pl. 5. The expanded tail and wing of a normal (94) to compare with the preceding is supplied in pl. 6. These illustrations show: (1) the degree of whitening attained in this "mutant"; (2) that a slight advance toward the normal darker color was attained by this bird in the second tail plumage; (3) that the (very) dark centers of the body

¹ The editor is responsible for the textual statement of this entire chapter and for the tabulated breeding records after 1910.

² These data, together with those on fertility and longevity, were supplied almost entirely by the editor, 1911 to 1915.

and wing coverts are particularly affected with white; and (4) that the uniformly dark feathers, such as primaries, secondaries, and rectrices, are more or less uniformly grayed or whitened.

In pl. 6 the extent of the variation of the second "mutant" (No. 98) is shown along with the two parents. It will be seen that this bird is more strongly whitened than was the preceding, but somewhat less so than the succeeding and final "mutant." This second variant, like the first, was short-lived, and no further history or illustrations of it are available.

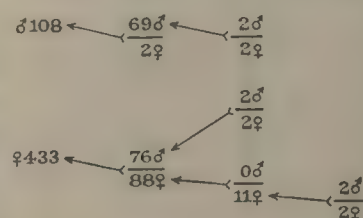
The last and most interesting of these "mutants" (No. 108) is shown at two years of age in pl. 7. It will be observed that this final "mutant" was perhaps the most striking variant of the series, and that the variant state had maintained its exhibition throughout various molting periods. The nearly white tail and the absolute displacement by white of the typical dark centers of the individual feathers are well shown. This bird was perhaps less wild, and notably more quiet, than any individual of this species that the editor has observed.

THE BREEDING OF MUTANT NO. 108.

Only No. 108 of these birds lived to maturity, and it only therefore was available for breeding tests. This bird proved to be a male, but refused to mate during 1911. In 1912 it mated with an immature relative (No. 433, hatched August 2, 1911). The relationship of these birds is completely given in the accompanying sketch or diagram. The chief interest in breeding No. 108 lies, of course, in determining whether the bird is a real mutant, *i.e.*, whether the marked somatic aberrations from the type pertain also to its germs. The illustration already referred to shows how strikingly this bird differed from the parent species. We elsewhere (legend of pl. 7) record Dr. Whitman's interpretation of this marked "mutation" as the outcome of a "weakened germ"—weakness associated with extreme age of the dam and inbreeding.

The result of mating this "mutant" with the pure Japanese turtle (433) mentioned above is shown in table 20, and is of the greatest interest in connection with the questions of the heritability of the variation, of the effect of season, overwork, and inbreeding in "weakening" germs.

It will be seen that from this pair 11 young were hatched, and lived long enough to admit of their classification as normal or "mutant." Of these, 6 were normal



EXPLANATION OF PLATE 4.

- A. Expanded tail of normal Japanese turtle-dove, *Turtur orientalis*, No. 94, of similar age with "mutant" No. 95.
- B. "Mutant" Japanese turtle-dove No. 95 and normal No. 94. Of similar age; photographed together, Sept. 17, 1909, to show contrast.

No. 95 is much whitened in coverts, tail, neck-marks, and, in fact throughout the entire plumage. The dam of this bird is now (Sept. 1909) at least 13 years old. She was imported in 1897, and at that time must have been one or more years old. The old age of the dam and the mating with her son accounts for the very light color of the young.

- C. Profile view of "mutant" No. 95.

This bird was the first to appear of three "mutants" of *T. orientalis*. It was the least striking color variant of the three. It developed from an egg of Aug. 15, 1909. Photographed, Sept. 17, 1909. For pedigree see table 19.



A



C

- A. Expanded tail of normal Japanese turtle-dove, *Turtur orientalis* No. 94, of similar age with "mutant" No. 95.
 B. "Mutant" No. 95 and normal No. 94, Japanese turtle-doves of similar age.
 C. Profile view of "mutant" No. 95. This was the first to appear of three "mutants" of *T. orientalis*. It was the least striking color variant of the three. It developed from an egg of Aug. 15, 1909. Photographed Sept. 17, 1909.



A



B

- A. Expanded tail-feathers of Japanese turtle-dove, *T. orientalis*, "mutant" female No. 95; plucked and mounted Sept. 20, 1909.
- B. Expanded wings and tail of Japanese turtle-dove "mutant" No. 95, at time of death, Oct. 14, 1909. The replacement of the dark centers of the wing and body coverts with white is well shown. The normally dark primaries and rectrices are here shown more or less uniformly grayed or whitened. The second growth of rectrices, shown expanded in the lower figure, have probably become slightly darker than in the first feathers, shown in fig. A

in their early plumages and 5 were abnormal—abnormal in the direction of their mutational male parent—and the last 2 most decidedly like their “mutant” father. Further, the normal offspring arose from the earlier eggs of the season—the first 5 and the seventh eggs producing the normals. The 5 mutants were from the last 6 eggs permitting a decision, while the last 4 birds of the season were all “mutational,” the last pair most strikingly of all. The first “mutant,” the sixth egg from the last, was the least decisively mutational of all. Thus from the first of the season to late season this series of offspring exhibited the characters under examination in essentially the following order: normality, slightly mutational, more mutational, most mutational. Photographs of 8 of these young, the 5 mutants and 3 normals, are shown in pl. 7. All of these young, and the parents as well, were photographed on the same day, September 29, 1912.

It would seem, therefore: (1) that the male parent is a “true mutation,” having given the breeding test; (2) that early in the season the “mutation” is recessive to the normal, but at the end of the season is dominant to the normal; and (3) that a “graduated increase of dominance” is indicated by the lesser amount of white in the earlier as compared with the greater amount of white in the later offspring.

The situation is, of course, not what one would expect on the basis of the mutation theory and of Mendelism, but in such terms as are used under (1) and (2) above it might be described, if one should feel obliged, even in the face of difficulties, to cling still to “qualitative” interpretations of heredity phenomena. And, if one had closed his note-book in September or October 1912 and were oblivious to facts which deal with the history and longevity of offspring and of parents, and with the “strength” of germs as affected by consanguinity, season, and overwork at reproduction, one would have occasion to learn little of the nature and basis of these phenomena of inheritance.

With these latter data before us, however, we perceive that a truer description of this inheritance embraces little of hypothetical factorial elaboration and symbolism. When these two weak birds (the sire lived 30 months, the dam 28 months) produced their strongest germs, known from other studies to be from the earlier part of the season, apparently normal (but weak and short-lived) offspring were produced. The later, still weaker germs reproduced the striking abnormalities of the “mutant” father, and for the same general reason that these same abnormalities were originally produced in him, namely, that the level of developmental strength has been lowered—the potency of the germ-plasm shifted. That, however, a special reason, namely, the weak “mutant” condition of the father, is a prominent “explanatory” feature of the ready and consistent attainment of this weakened “mutant” condition of his offspring, can not be doubted. In this male the general developmental power and the specific power to produce certain parts of the color pattern were subnormal, and under conditions which are otherwise known to reduce the developmental level of germs the germs of this pair were easily, quickly, and consistently thrown into the exhibition of a similar low level of developmental strength; and this low level of color-pattern has, moreover, been found only in the immediate group to which the father belonged and in his offspring.

Moreover, a quite complete explanation of the situation involved here can not be given without attention also to the later history of the *mother* of this group.

The eggs which produced these "mutant" young were at the same time her last in life, though she lived more than 15 months after their production, and was then killed only by rather exceptional exposure. Very probably, however, she would have laid other eggs if she had been able to gain a perch and copulate. These things she was unable to do because in the late summer of 1912, *at the close of the overwork incident to the production of the series of eggs now under discussion*, she was unable adequately to renew her flight and tail feathers. Indeed, she remained permanently quite unable to renew more than a fraction of her plumage; at the time of death she was provided with very few body coverts and most other feathers were stunted and incomplete. It will thus be seen that the mother of this group of young was plainly a weaker organism at the extreme end of the season, when the dominance of the father's mutational characteristics became complete. The general weakness of the two parents no doubt coöperated in additional defects, abnormalities, and weakness which obtained in the entire series, but which, like the "mutational" character, were accentuated at the very end of the series.

But if some shall incline to assume that a germinal basis—a basis of genetic significance—is not involved in this instance and that these features might have been purely somatic in their nature, such assumptions may be brought to face the following further facts:

(1) The two most strikingly mutant young—the very last of the season—had "club feet" (in addition to the whitened mutational plumage), and one of these

EXPLANATION OF PLATE 7.

A. Figure on left: Japanese turtle "mutant" No. 108 and mate No. 433.

These are the parents of the other birds shown on this plate. The whitened "mutant" parent is shown to the left; the normal mate to the right. All birds of this plate photographed Sept. 29, 1912. "No. 108 was hatched Sept. 22, 1910. On Oct. 12, it is found that the dark centers of the juvenal feathers are replaced by *white!* The bird is a close copy of No. 98, and whitened for the same reason—the *old age* of the dam and *inbreeding*. Photographed in full juvenal plumage Nov. 25, 1910." (The photographs taken Nov. 25, 1910, proved unsuitable for reproduction; they served, however, to show that the later plumages of this bird were not perceptibly different from the first plumage.—Ed.)

Middle figure: One of the earlier normal offspring (891) of the above pair. The coloration was quite normal. Before death, however, the plumage of this bird showed a decided tendency to whiten.

Figure on right: The earliest of the young (826) of this series which was photographed. The bird was photographed in strong light, but the coloration was perfectly normal.

B. The first two partial "mutants" and an intervening normal young from the parents shown under A.

Figure on left: Male No. 879 with whitened tail-feathers, and with otherwise normal coloration. This was the second partial "mutant."

Middle figure: Female No. 880 with normal coloration throughout. In last plumage preceding death, however, there appeared several whitened feathers.

Figure on right: Female No. 861 with whitened tail and some gray and white in flight feathers. This was the third partial "mutant" of the series.

C. The last three "mutant" offspring of "mutant" No. 108 and normal No. 433.

Figure on left: Female No. 874; the fourth partial "mutant" of the season. Not only the tail, but some primaries, secondaries, and tertials were here whitened.

Middle figure: Male No. 859; one of the last pair of "mutants;" from the extreme end of the season. This bird has a white tail; mostly gray to white primaries, secondaries, tertials, and body coverts generally. Whole aspect extremely light. The feathering, particularly the primaries, was deficient in first and in later plumages. The bird had a "club foot" (the left).

Figure on right: No. 801 (sex ?); last "mutant;" nest-mate of above bird and quite similar to it in color and feathering. It also had "club feet" (one of which is shown in the illustration) and but a single kidney.

For the origin of the several young shown on this plate see table 20.



A, B. Wing and expanded tail of a normal Japanese turtle-dove, *T. orientalis*, No. 94 (4 weeks 4 days old). For comparison with pl. 5.

C, D. Japanese turtle-dove "mutant" No. 98 (second "mutant"), with parents, male *T. orientalis* (69) and female *T. orientalis* (2). From egg of April 2, 1910. Photographed May 20, 1910. The extent of white in the young and the perfect normality of the visible characters of the parents are shown. No. 98 is like No. 95, but considerably whiter. The juvenal feathers have the reddish edge followed by a thin border of black, the center being white. This "mutant" died July 9, 1910, with some of its adult feathers already in place; in these feathers the thin border of black has been perceptibly widened, while the center of the feather remains white or very light gray. The dam seems in fairly good health but rather heavy in motion, especially in flight. She flies up to her nest—about 7 feet—regularly, however, and often attains it by a nearly vertical flight.

A



B



A. Figure on left: Japanese turtle "mutant" No. 108 and mate No. 433. These are the parents of the other birds shown on this plate. The whitened "mutant" parent is shown to the left; the normal mate to the right.
 B. The first two partial "mutants" and an intervening normal young from the parents noted above.
 C. The last three "mutant" offspring of "mutant" No. 108 and normal No. 433.

birds was found at autopsy to have but a *single kidney*; such phenomena of development are inconceivable on any other ground than that the "germinal bases" of these characters were modified. These several germinal modifications were all associated in precisely the two most strikingly "mutant" young.

(2) The entire family of about 17 young (including embryos) show a significantly restricted term of life, demonstrating that gametes of reduced potency were being generally produced; furthermore, at least 4 eggs tested absolutely infertile.

(3) The mutational features here, like most mutations hitherto observed, involve the *loss* of characters.

(4) That the white mutational mark was not an adventitious somatic mark of temporary value was proved by the fact that the parent "mutant" lived for $2\frac{1}{2}$ years and that it suffered no apparent change, certainly no reduction of white, in its several plumages, while the "mutant" offspring of this bird replaced, when adult, their "mutational" first plumages with similar or identical or intensified "mutant" plumages. Furthermore, the last two "normal" birds of the season classified as "normal" in their first plumage showed advances toward the "mutant" condition in feathers developed later. This fact is described in detail in the section treating of the autopsies of this family. The mutational characters in question were, therefore, rather accentuated than diminished in the individual ontogenesis.

(5) Finally, though breeding tests were limited in this case to the data already given, such breeding tests have been quite thoroughly made in the case of at least two seemingly quite analogous cases: (a) The "*Zenaida* mutation," noted in Chapter X and fully described and illustrated in Volume I. This later mutation has to do with the appearance of a white triangular mark in the feather-tips of the general plumage. Here, too, the original "mutant" arose in *September*—again the period of weakest germs. And (b) a second case, the "guinea-pigeon mutation," in which a loss of red, a *lightening* of the general color in the direction of the rock-pigeon, occurred, and which was likewise shown to be inherited in a fraction of the offspring. This latter "mutation" is also fully illustrated and described in Volume I (Chapter IX) of these works.

AUTOPSIES OF *T. ORIENTALIS* NO. 108 AND NO. 433 AND OF THEIR YOUNG, HATCHED IN 1912.

An answer to many questions which will arise in connection with the highly interesting family just described can be supplied only by the following information secured at the time of death of the various members of the family. The detailed statement concerning the "mutational" exhibitions of the several individuals concerned is also best given here.

Autopsy, 108♂.—Found dead March 8, 1913. On the previous day this bird did not seem sick, and at no previous time was it thought to be sick. Weight on February 18, 1913, showed, however, that the bird was considerably too light (218 grams). Was always a very quiet bird. Two *small* testes, two normal kidneys,³ and other viscera apparently normal, though feces somewhat greenish; a little food in crop. An evident collection of white mucus-like material at internal nostrils, but no canker found; brain apparently normal. Indeed, the examination failed to show why this bird

³ The last of the young (801) of the 1912 series was found December 13, 1912, to have but a single kidney. The parents and the other offspring which died later than did No. 801 were examined to see whether, by any chance, another instance of this unusual abnormality might be found in the same family.

should have died. Organs other than above noted seemed healthy. Wings, tail, and part of skin preserved; these whitened essentially as in all previous plumages. It was found that just proximal to the bronze edge of most feathers was to be found a very narrow black edge (this of course followed here also by white-to-gray) in many body and wing feathers.

Autopsy, 433 ♀.—Died November 27, 1913, on trip Chicago to New York; a nearly "naked" bird; was hardly expected to make trip successfully. Feathers present, mostly stunted and stubby. Two kidneys; no worms found; death apparently from weakness, exposure, and naked condition. Examined more than 24 hours after death.

AUTOPSIES OF YOUNG OF ABOVE PAIR IN ORDER OF HATCHING.

Autopsy, 895 ♀.—Died September 18, 1912. Nothing special noted other than the sex. Any change in color from its earlier state would certainly have been noted.

Autopsy, 885 ♂.—Died July 19, 1912. Dead in my absence and bird not fresh when examined. It had maintained its normal color or this would certainly have been remarked.

Autopsy, 826 ♂.—Died March 1, 1913. Emaciated; very small testes; two kidneys; left ureter distended with whitish semi-fluid (uric acid, etc.); right ureter empty. Color normal.

Autopsy, 818.—Disappeared (probably died) at 9 or 10 months. No white color had been noted in this bird. Sex unknown.

Autopsy, 891 ♀.—Died April 13, 1913. Ovary rather well developed; two kidneys; worms in greenish intestines; no tuberculosis.

The 6 old (full-grown) rectrices were normal color, but 6 short, newly growing (?) ones were all plainly grayed or whitened. 4 of the "mutant" feathers were on the right of center and 2 on left. (The 2 center feathers were "mutants.")

Right wing—Primaries: 1, normal color, long but worn; 2, normal color for half-length, then stunted and constricted at base, and showed a very narrow edge of white; 3, very small and short, apparently normal color; 4, still smaller, apparently normal color; 5, still smaller and apparently normal color; 6, small (size of 3), apparently normal color; 7, very small (size of 4), nearly pure white; 8, very small (size of 4), somewhat whitened; 9, very small and slender, somewhat whitened; 10, too rudimentary to study.

Secondaries: These normal color, but coverts of first 5 were all young, growing (?), and whitish. All old full-size secondary coverts were of normal color.

Left wing—Primaries: 1, old, broken off short; 2 to 6 (inclusive) very short (4 to 20 mm.); 7, inclosed in follicle, but whitened. 8, 9, 10 very short (10 to 16 mm.), of apparently normal color, except on extreme tip, where there was a very narrow edging of pure white.

Secondaries: Old long ones all normal color. Coverts nearly all normal; but the fourth, and possibly 1 or 2 more of the young and small ones, were whitened.

Autopsy, 879 ♂.—Died April 2, 1913. Testes exceedingly small, each less than half size of grain of wheat. Two kidneys. Probably digestive troubles; little or not at all emaciated. Except intestines, all organs seemed healthy. Primaries, secondaries, the primary coverts and body coverts normal or nearly normal. Possibly tertials were more gray than usual. Rectrices short and whitish or grayish-white, mixed with ashen-gray.

Autopsy, 880 ♀.—Died April 20, 1913. No trace of tuberculosis; intestines greenish, but no worms found; 1 and 3 days previous to death *santonine* given to expel worms suspected of being present.

Rectrices: 5 on left side, 6 on right; fourth from center here is short and nearly completely white.

Primaries: Of both wings all very short; longest = $1\frac{1}{4}$ inches. Bases of nearly, but not quite, all were constricted.

Secondaries: Four of these full length and normal color on left wing; others here small, 2 of them (first and second, or second and third) a bit whitened at tip. On right wing these latter feathers were smaller and very slightly whitened likewise. Here 5 secondaries were normal length and color; others small.

Tertials: One tertial of left wing was grayed on basal half.

Autopsy, 861 ♀.—Died at noon March 17, 1913. On this morning noted for first time that bird was not well. Slight intestinal (green) trouble, but hardly cause of death; this not revealed by autopsy. Crop and gizzard with food; liver, lungs, and heart apparently normal. Two kidneys; mouth and head normal. Only stubby rectrices and primaries. Rectrices white or very gray; bases of most but not of all these constricted and growth stopped.

Autopsy, 874 ♀.—Died April 9, 1913. A female with a fairly well developed ovary. Eggs about 1 mm. diameter; two kidneys. Rather greenish intestines, with worms. The intestine may have been perforated by one of two large worms ($1\frac{1}{4}$ inches long). No trace of tuberculosis.

Rectrices and coverts white or whitened when present, except for two middle rectrices which were normal (ends broken off). These perfect rectrices had no obvious constrictions at bases; practically all others did. These latter mostly short and obviously stunted. Not a single full-grown primary in either wing, and but one full-grown secondary (normal color it was) in the two wings. Most of the stunted secondaries and their coverts were gray or whitened at one or all parts, and 2 tertials were found to be obviously turned to gray in their unfolded portions not far above the terminal constrictions.

Autopsy, 859♂.—Died March 26, 1913. Two kidneys; left foot with toes curled and useless; testes small, not emaciated, but bird small; yellowish over peritoneum and pericardium; also diseased (yellowish) streak within wall of gizzard. Primaries, secondaries, and rectrices all, or nearly all, stubby, broken, contracted roots—many of these whitened.

Autopsy, 801.—Died December 13, 1912. Sex doubtful; undeveloped gonads, two in number. Only one kidney, with the normal site of the other perfectly clean, whitish bone, free of tissue! Feathers much stunted; color white to very gray. Always a weak bird; two "club" feet.

INBREEDING, FERTILITY, AND LONGEVITY IN THE OFFSPRING OF JAPANESE TURTLE DOVES OF PAIRS 4 AND 5.

In view of the results of the breeding of "mutant" 108, as just given, it will now be well to present data upon the breeding and inbreeding of his brothers and sisters; also these data for his half brothers and sisters, and further the facts learned from crossing many of these individuals with other species—*St. risoria* and *St. alba*.

Brother-and-sister matings.—Five pairs of the earlier young of ♂ *T. orientalis* (2) × ♀ *T. orientalis* (2) were mated *inter se*. The results show that the germs of related doves do not attain the strength of the germs which produced the parents themselves. In only a single instance did any of the numerous eggs of these matings produce a young that lived as long as its shorter-lived parent. These matings—22 × 21, 22 × 14, 25 × 23, 40] × 60, 35 × 30—are treated fully in the accompanying tables, and briefly in the following paragraphs. The origin of all the birds concerned may be seen in table 19.

In the first of these matings of brother and sister, both parents being under maturity, the average life of (3) offspring is (for 22 × 21) 2½ months. For 14 × 21, when both parents were 1 year older, this average (for 4) is 9 months. The total production of eggs for pair 22 × 21 (table 21) during more than a year is only 8; and 50 per cent of these were unhatchable. The same female when a year older and with an older mate produced at least 8 eggs in less than a year and all of those tested (4) were hatched. The early death of the male of the 22 × 21 mating is a further pertinent fact in a consideration of the weakness of those germs.

When the birds of the next mating (25 × 23) were but little more than a year old they were able to hatch 2 young; at 2 years 4 of 6 eggs hatched, but the young were short-lived. In their third year the only 2 eggs known to have been laid were hatched; the young again were probably short-lived (table 22). The immature brothers and sisters, in mating 40 × 60 and 35 × 30 (table 22), gave progeny (3) with an average length of life of 3 months, with one striking exception (from 35 × 30), which lived about 60 months. It is notable that the male parent of this exception lived longer than any other bird of the group of parents now being considered (and at 10 years is still alive and partially fertile with an overworked *St. alba*). In 7 of the 8 pairs of eggs for which the data are adequate, the first egg of the clutch produced a stronger or longer-lived bird than did the second egg.

Reproductive overwork does not play a part in these several matings; immaturity and inbreeding are the obvious causes of the production of these several lots of extraordinarily short-lived offspring.

Crosses with Streptopelia.—Before undertaking a consideration of inbreeding in other than brother-and-sister matings it will be well to note the results of crossing members of the family under consideration with two species of a related genus. It will here become apparent that the earlier stronger, non-inbred young of pair 4 (♂ *T. orientalis*, 2 × ♀ *T. orientalis*, 2) are highly fertile, and their offspring are long-lived. On the other hand, similar crosses of the brothers and sisters of the "mutant" No. 108 (from pair 5 = ♂69 × ♀2) were less fertile, and their offspring lived less long. These data have been condensed as much as possible, and the references to the tabulated data given under two headings soon to follow.

The records for female No. 99, covering a period of 4 years, are given in tables 23 and 24 and present the following situation: (1) This apparently normal bird, from one of a series of germs containing some obviously weak ones, was in reality also a weak bird, at least in respect to fertility. (2) Fertility, or developmental power, is weak between her and a species with which her species is normally quite fertile. (3) During her own lifetime this female presents a sliding scale of fertility. Highest fertility was reached in her second reproductive year (1912). In the third year, from 17 efforts only 2 were hatched, and 1 additional embryo (1 to 2 days?) formed. In her fourth year her eggs showed no trace of development. (4) In this fourth year many clutches of 1 egg only were laid.⁴

The results from the brother, No. 105, were still less favorable, as may be seen from the condensed statement given below and from table 25. This male was so little aggressive that he failed to win as mates 3 of the females long kept with him. In his fourth year, the last test, he was more fertile than formerly; but for 5 months following that period he remained idle while confined with his sister (99), whose record has just been given.

The condensed fertility records given below will facilitate a detailed comparison, by those particularly interested in the matter, of the relative fertility of the inbred and the non-inbred members of this family. The relative longevity which is associated with the different levels of fertility is also displayed by these records and by the tables to which these records refer.

CONDENSED FERTILITY RECORDS OF NON-INBRED OFFSPRING OF ♂ *T. ORIENTALIS* 2 × ♀ *T. ORIENTALIS* 2.

♀ 13. *T. orientalis*; 5/28/03; 3/4/06; 2 yr. 10 mo.

During the years 1904 and 1905 this bird proved mostly fertile with *St. risoria* (table 47), and the offspring were long-lived.

♂ 14. *T. orientalis*; 7/6/03; 6/3/09; 5 yr. 11 mo.

In 1904 tested fully fertile with *St. risoria*; the young were long-lived (table 48). Fertility with a sister (in 1907) was considerably lower, and the term of life of the offspring was much shorter (table 21).

⁴ It may be further noted that investigation (by O. R.) of the egg-yolks of this bird has furnished two interesting facts: (a) the yolks are all abnormally small for this species; (b) the normal size relations between first and second egg do not obtain. Whereas, in this species, the yolk of the first egg in a large percentage of cases is smaller than the second, the 11 pairs of eggs for which we have perfect weighings show 5 clutches with the first egg larger, 5 in which the second is larger, and one in which they are equal. Note that the breeding data of 1912 correspondingly show less developmental energy in the first egg of two clutches (H, J), and more in the first of two other clutches (D, E). In one other (G) it is different, but the order of the eggs is unknown. And similarly, this bird, contrary to the normal for the species, is as likely to throw a female from the first egg (C, D, E) as from the second (H, J).

♂ 35. *T. orientalis*; 8/13/04; 10/1/14; 10+ yr.

This bird has a long and important history of matings with *St. alba*. This is given in tables 37 to 41. He has been tested with five different females. With the first four he was fully fertile and the offspring were long lived. With the fifth—when the male was 10 years old and the female previously overworked—two clutches (4 eggs) only were produced in 4 months; one egg was entirely infertile; a second produced a weak crippled (right leg straight and horizontal) young that lived for 2 months and showed on autopsy no gonad whatsoever!

♂ 40. *T. orientalis*; 4/28/05; 5/1/13; 8 yr.

The mating of this bird with a sister (No. 60) in 1907 is given in table 22. These birds were then infertile. The record 1908-10, inclusive, is not known. During 1911 this male kept with a female *alba* × *orientalis* hybrid (12) without mating. Continued 1912 until Sept. 3 without result. When offered *T. orientalis* No. 88 she was accepted at once and a few fertile eggs produced, as indicated in detail elsewhere (table 26a).

♂ 66. *T. orientalis*; 6/6/06; alive 7/2/07; 1+ yr.

Tests made only with the usually infertile, or little fertile, *risoria* × *orientalis* hyb. (2). The pair proved partially fertile in 1907 (table 51).

♂ 69. *T. orientalis*; 7/17/06; alive 9/1/14; 8+ yr.

During 1909 and 1910 this male mated with his mother and produced whitened "mutant" offspring as shown in table 19. Until October 17, 1911, this bird was with a female *St. alba*, with which it probably mated and produced a few eggs, the fertility of which is not known. After the above date put with a female *orientalis* × *alba* hybrid (27); no eggs during the autumn. These birds produced during 1912, 64 eggs, 39 of these were tested for fertility and all proved absolutely infertile; these hybrids and their reciprocals are usually quite infertile. Before May 16, 1913, 23 eggs were produced; none tested for fertility. From May 16 to September 30 No. 69 was with female *T. orientalis* No. 433 (hardly sufficient feathers to fly) without mating. From September 30, 1913, to 1914 this male was with a female *T. orientalis* (429), whose record is given in table 30. These two related birds gave poor results.

♂ 76. *T. orientalis*; 3/17/07; stolen 8/12/12; 5+ yr.

In 1909 this bird was fully fertile (3 eggs) with an *orientalis* (38) of uncertain ancestry; in 1910, when mated to his immature niece (88), he was probably fully fertile (table 26), but the young were short-lived. During 1911 this more mature mating was fully fertile (26 young), and the offspring lived longer (table 27) than did those from the previous matings. It is upon this family (of 1911) that chapter 6 is based. From about March 1912 this male was without opportunity to mate until June 12; then with female *St. alba* (459) without mating, stolen August 12, 1912.

CONDENSED FERTILITY RECORD OF INBRED OFFSPRING OF FEMALE *T. ORIENTALIS* NO. 2, WHEN OLD AND MATED TO A SON, NO. 69.

♀ 99. *T. orientalis*; 6/4/10; alive 10/1/14; 4+ yr.

Mated with her brother (105), this female produced 2 eggs about May 20, 1911. July 2, 1911, she was given a female *alba* × *orientalis* hyb. (27), with whom a mating possibly occurred; but No. 99 probably laid no eggs. On September 17 she was put in a cage with 2 unmated birds—male *St. alba* (226) and female *T. orientalis* (2); no result. On April 24, 1912, put with a male *St. alba* (462) and was then fully fertile, as is shown in table 23; later she largely lost fertility, as shown in table 24. Kept October 24, 1914, to March 20, 1915, with a brother (No. 105) without results.

♂ 105. *T. orientalis*; 7/25/10; alive 10/1/14; 4+ yr.

In 1911 this male till July 2 with his sister (99). A clutch was produced by the pair; these crushed, probably fertile. After July 2 with female *alba* × *orientalis* hyb. (27); failed to mate. May 30 to September 3, 1912, with a *St. alba* (died October 9, 1912) without result. September 3 to October 11 with female *St. alba* (492) (died December 9, 1912) without result; after October 11, 1912, with male *T. orientalis* (446). During 1913 (after April 30) and 1914 mated with female *St. alba* (817); this pair in 1913 produced infertile eggs (female was rather young); in 1914, many infertile and some fully fertile eggs, as shown in table 25. Kept October 24, 1914, to March 20, 1915, with sister (99) without result.

♂ 108. *T. orientalis* ("mutant"); 9/7/10; 3/18/13; 2 yr. 6 mo.

This male put May 23, 1911 with a one year old male *T. orientalis* (101). The sex of neither was known; they remained together without mating behavior; but the "mutant" was twice recorded as "in the nest." From August 3 to October 13 male *St. alba* (26) was given. On March 22, 1912; this male was given female *T. orientalis* 433, which had laid one or two clutches of eggs; a mating was effected at once. The interesting result of this mating is given in table 20. These birds were kept together during the winter of 1912-13 without eggs; though the failure was probably the fault of the female, which was insufficiently provided with feathers, particularly flight feathers. The male, always a very quiet bird, was thought, till found dead, to be healthy (though too light=218 g. instead of 240 to 250 on February 18, 1913). The autopsy failed to reveal the cause of death; the testes were remarkably small.

♀ 109. *T. orientalis*; 9/9/10; 9/3/12; 2 yr.

On July 2, 1911 a female *alba* × *orientalis* hyb. (10) was given; this latter female laid a clutch of eggs, and developed (in ovary) another clutch before removal on August 4, but ♀ 109 laid no eggs and showed no signs of mating. On August 4 a male *St. alba* (228) was given with no result. From early 1912 to June 2 with male *St. alba* (459) with no result. From June 2 till dead on September 3 with a female *St. alba* (492). The latter bird (dead December 9, 1912) laid 10 eggs during this time—all, of course, infertile; ♀ 109 laid none. It was not thought, till autopsy, that this bird was a female. In view of the above record of two different females having laid eggs when confined with this bird, it seems not improbable that an actual mating occurred in each instance; but this weak female was perhaps "unable to produce eggs" under this degree or kind of stimulus; perhaps this history raises a question as to her power to produce eggs at all.

INBREEDING OF UNCLE TO NIECE AND ORIGIN OF AN INTERESTING FAMILY OF INBREDS.

Besides the male "mutant" No. 108, whose mating with a relative has been described at length, 3 of the offspring of his mother, *T. orientalis* 2, were inbred, but in other than brother-and-sister matings, and founded stock not strong, although strong enough to reproduce, and thus permit a further study of the effects on the germs of continued inbreeding in these doves. In general the matings given here are of uncle and niece. One such pair yielded a large family of inbreds which become the center of interest in the next chapter. The data for this degree of inbreeding is presented in three tables given herewith. These data strongly reinforce those derived from the brother-and-sister matings, and from inbred birds out-crossed to other species, in that they indicate that *these immature and inbred doves may produce offspring; but not offspring that will live the normal span of life*. The following statement sufficiently analyzes the individual matings:

The shortest and least instructive mating of the series concerns a male (40) which, when not fully mature, tested at least partially fertile with a sister (table 22). With a niece (88) this male was given two further tests of fertility (table 26A); these two eggs hatched, but the young from the second egg of the clutch (laid last of *September*) lived but 3 days. The other bird was a female that lived for 6 months.

The individual tabular records for male No. 76, during 3 years of matings, bring out the following facts: When the male was little more than 2 years old, and mated with a female of unknown ancestry though probably related and probably 3 or 4 years old, the progeny (3) averaged probably 9 to 10 months (table 26). But when 3 years old, mated to an immature (2 years old) daughter of his sister (88), only one of 7 young lived as long as 9 months. This one, however, from a strong germ of the latter part of May, escaped at 25 months. 4 of the 7 young died at the age of 5 to 9 months, and the last 2 of the season at only 1 month (table 26). During the following year (1911), when the male was a little more than 4 years old and his consort was reaching maturity (3 years), the progeny (about 25) lived 24+ months (3 still alive). This particular family, whose detailed history is given in table 27, it will be noted, is a large one and was produced under overwork; the term of life of the offspring was, however, sufficiently long to permit breeding tests with many of them. The results of the further special study of this family will be given in the following chapter.

The last pair of eggs for the seasons 1910 and 1911 produced birds with the *shortest* life-term; and the *longest* life-terms are grouped toward the earlier part of the season. Birds from the first egg of 3 clutches lived longer than birds from the second; less long in 1 or (?) 2 cases.

The sex data for the progeny of this male and his two consorts are in many respects meager and incomplete; combined with the data for longevity, they may be compactly given as follows:

1909, the (7 related) nearly mature mate gave.....	2♂; 0♀; 1? (?9½ months).
1910, the inbred, immature mate gave.....	1♂; 2♀; 5? (?8 months).
1911, the inbred, less immature mate gave.....	7♂; 9♀; 9? (24+ months).

When, therefore, the parents were more mature, the progeny lived longer; probably there was then, too, a higher proportion of males.

A similar summary statement for the second of the two females (88) used in the above matings is of interest. It will be noted that female No. 88, herself the

strongest of a weak progeny (table 18A), produced inbred offspring from 2 different males (uncles) during 3 years—her second, third, and fourth years. The number of eggs, offspring, and the data for sex and longevity from these three years (tables 26, 27, 26A) is as follows:

1910 (♂76), 10 eggs, 10 tested, 8 hatched, 1♂, 2♀, 5? (78 months).
 1911 (♂76), 30 eggs, 25 tested, 25 hatched, 7♂, 9♀, 9? (26+ months).
 1912 (♂40), 10 eggs, 2 tested, 2 hatched, 0♂, 1♀, 1? (3½ months).

It is obvious, therefore, that, in the inbreeding of uncle and niece, among Japanese turtle-doves, a long-lived progeny is difficult to obtain. The results are, however, more favorable than were obtained in the brother-and-sister matings. They are at the same time less favorable than the out-crosses with *Streptopelia*. These several matings all disclose the weakness of the last germs of the season.

The large family produced in the uncle-and-niece mating of 1911, whose origin in detail is given in table 27, becomes, in the next chapter, the subject of a further study on the relation of "season of hatching" to "fertility."

TABLE 20.

♂ 108 "Mutant" *T. orientalis*; "much white" 9/7/10. 3/8/13; 30 mo. 1 da. (see pl. 7).

♀ 433 Normal (?) *T. orientalis*; 7/18/11. 11/27/13; 28 mo. 9 da. (see pl. 7).

The parents are both inbreds, and are related (see sketch of this, page 42).

AA 1. 3/19/12; ? deserted.			
AA 2. 3/21/12; ? deserted.			
A 1. 4/1; no development.		C 1. 4/28; no development.	
A 2. 4/3; no development.		C 2. 4/30; no development.	
B 1. 4/19; not tested.		D 1. 5/8; trace development.	
B 2. 4/21; soft shell.		D 2. 5/10; 4 to 5 day embryo.	
♀ E 1. 5/30. normal	895.	dead 9/18/12.	3 mo. 15 da.
♂ E 2. 6/1. normal	885.	dead 7/19/12.	1 mo. 18 da.
F 1. 6/8; not tested (analysis).			
F 2. 6/10; not tested (analysis).			
♂ G 1. 6/18. normal	826.	dead 3/1/13.	8 mo. 12 da. (see pl. 7)
G 2. 6/20; trace, or no development.			
H 1. 6/27. normal	818.	disappeared (probably dead) at 9 or 10 mo.	
H 2. 6/29; failed to hatch.			
I 1. 7/6; 13 day embryo (irregular incubation).			
♀ I 2. 7/8. normal	891.	dead 4/13/13.	9 mo. 5 da. (see pl. 7)
♂ J 1. 7/14. white tail	879.	dead 4/2/13.	8 mo. 19 da. (see pl. 7)
♀ J 2. 7/16. normal	880.	dead 4/20/13.	9 mo. 4 da. (see pl. 7)
K 1. 7/24; on ground, broken.			
K 2. 7/26. hatched 8/10.		dead 8/12/12.	17 da.
♀ L 1. 8/1) one white tail +	861.	dead 3/17/13.	7 mo. 17 da. (see pl. 7)
♀ L 2. 8/3) other white tail +	874.	dead 4/9/13.	8 mo. 6 da. (see pl. 7)
♂ and ? M 1. 8/12) one much white ¹	859♂.	dead 3/26/13.	7 mo. 14 da. (see pl. 7)
M 2. 8/14) other much white ²	801 (?)	dead 12/13/12.	4 mo. (see pl. 7)

In 1913 this female refused to mate with male *T. orientalis* (69). She died from exposure (was nearly naked) on trip—Chicago to New York—more than 15 months after the close of the above record. From 9/30 to 11/26/13 she was with a *St. alba* (♂672) without mating (could not gain perch). (O. R.)

¹ Also club feet, defective feathering.

² Also club feet, defective feathering, and only one kidney.

TABLE 21.

♂ *T. orientalis* (22); 9/20/03; brother; 6/19/06; (one blind eye); 33 mo.

♀ *T. orientalis* (21); 9/18/03; sister; 7/12/08; (has bad eye); 58+ mo.

A 1. 4/1/05; some development.			
A 2. 4/3/05; some development.			
B 1. 6/27. 50.	dead.	8/26/05.	2 mo.
B 2. 6/29; pricked shell, unable to hatch.			

TABLE 21 (continued)

C 1. 4/1/06.....63.....	dead.....	7/12/06.....	3 mo. 11 da.
C 2. 4/3/06; unhatched.			
D 1. 5/4.....64.....	dead.....	7/28/06.....	2 mo. 24 da.
D 2. 5/6.....65; dead.			

♂ 22 died 6/19/06.

In 1907 used ♂ *T. orientalis* 14, brother of ♀ 21; 7/6/03-6/3/09; 70 mo. 27 da.

?	1. ?/?/07; deserted.		?	1. ?/?/07; deserted.	
?	2. ?/?/07; deserted.		?	2. ?/?/07; deserted.	
A 1.	4/6.....80.....	dead (blind eye).....	12/5/07.....		8 mo.
A 2.	4/8.....	dead (blind eye).....	5/18/07.....		1 mo. 10 da.
B 1.	5/16.....83.....	dead.....	7/6/09.....		25 mo. 20 da.
B 2.	5/18.....	dead.....	6/8/07.....		20 da.

March to May several sets of eggs; none hatched till:

C 1.	5/26/08.....87; death not recorded.
C 2.	5/28/08; unhatched.

Female parent killed 7/12/08, with a bad eye.

(F 28)

TABLE 22.

♂ *T. orientalis* (25); 4/10/04; brother; no record of death.

♀ *T. orientalis* (23); 3/7/04; sister; no record of death.

A 1.	5/18/05; deserted.	E 1.	4/3/06; 62; hatched, probably short-lived.
A 2.	5/20/05; deserted.	E 2.	4/5/06; 63; hatched, probably short-lived.
B 1.	6/3; 48; lice-killed.	F 1.	Not hatched.
B 2.	6/5; 49; lice-killed.	F 2.	Not hatched.
C 1.	7/21; deserted.	♂ G 1.	9/12. 72. dead. 12/31/06.....3 mo. 19 da.
C 2.	7/23; deserted.	G 2.	9/14. 73. dead. "winter 1907"....4? mo.
D 1.	8/9; probably not hatched.	H 1.	6/4/07; hatched, probably short-lived.
D 2.	8/11; probably not hatched.	H 2.	6/6/07; hatched, probably short-lived.

♂ *T. orientalis* (35); 8/13/04; brother; alive 6/1/14; 118+ mo.

♀ *T. orientalis* (30); 7/7/04; sister; dead 3/?/06; 20 mo.

♀ A 1.	7/6/05.....53.....	dead.....	10/3/05.....	2 mo. 27 da.
A 2.	7/8/05; pricked shell, failed to hatch.			
♂ B 1.	8/17.....55.....	dead.....	12/20/05.....	4 mo. 3 da.
♀ B 2.	8/19.....54.....	dead.....	11/?/09-12/?/10(?).....	60 mo.

♀ 30 mated 1906 with a ♂ white ring-dove.

♂ 35 mated 1906-14 with ♀ white rings 67, 87, 8, 649, 772; (see tables 37 to 41).

♂ *T. orientalis* (40); 4/28/05; brother; 5/1/13; 96 mo. 3 da.

♀ *T. orientalis* (60); 3/27/06; sister.

♀ A 1.	7/8/07.....84.....	dead.....	10/20/07.....	3 mo. 12 da.
A 2.	7/10/07; no record; almost certainly not hatched.			(F 28)

TABLE 23.

♂ *St. alba* (462); (¾ *alba*-¼ *risoria*); May 1911; 10/31/14; 41 mo.

♀ *T. orientalis* (99); 6/4/10; alive; 4/1/15; 60+ mo.

♂ B 1.	6/18/12.....	dark.....	856.....	alive 4/1/15.....	33+ mo.
♂ B 2.	6/20/12.....	dark.....	836.....	alive 4/1/15.....	33+ mo.
♀ C 1.	6/28.....	white.....	866.....	escaped 6/1/13.	
♂ C 2.	6/30.....	dark.....	844.....	escaped or disappeared about 1/1/14.	
♀ D 1.	7/9.....	white.....	835.....	stolen 7/4/13.	
D 2.	7/11; little development.				
♀ E 1.	7/20.....	white.....	815.....	alive 4/1/15.	
E 2.	7/22; 6 to 7 day embryo.				
♀ G 1.	8/6.....	white.....	{one ?.....	dead 8/23/12.....	2 da.
♀ G 2.	8/8.....	white.....	{855.....	alive 4/1/15.....	32+ mo.
H 1.	8/13; no development.				
♀ H 2.	8/15.....	white.....	897.....	killed 9/18/12.	
♂ I 1.	8/23.....	dark.....	820.....	alive 4/1/15.....	31+ mo.
♂ I 2.	8/25.....	dark.....	860.....	alive 4/1/15.....	31+ mo.
J 1.	9/2; no development.				
♀ J 2.	9/4.....	white.....	896.....	alive 4/1/15.....	31+ mo.

(O. R.)

TABLE 24.

1913: ♂ *St. alba* (462) (con.).
♀ *T. orientalis* (99).

A 1. 1/30; analyzed.
A 2. 2/1; analyzed.
B 1. 2/9; analyzed.
B 2. 2/11; analyzed.
C. 2/19; weighed yolk.
D. 2/25; broken.
E 1. 3/5; no development.
E 2. 3/7; no development.
F 1. 3/16; no development.
F 2. 3/18; soft shell.
G 1. 3/27; weak shell.
G 2. 3/29; no shell.
H. 4/11; no development.
I. 4/21; broken.
J 1. 4/30; analyzed.
J 2. 5/2; analyzed.
K 1. 5/9; analyzed.
K 2. 5/11; analyzed.
L 1. 5/16; no development.
♂ L 2. 5/18; injured hatching; dark.
M 1. 5/23; no development.
M 2. 5/25; no development.
N 1. 5/31; analyzed.
N 2. 6/2; analyzed.
O 1. 6/9; no development.
O 2. 6/11; no development.

(Nested eggs here to give a rest).

P 1. 7/11; no development.
P 2. 7/13; 1 to 2 day development.
Q 1. 7/22; no development.
♂ Q 2. 7/24; 760; dark; alive 8/1 '14.
R 1. 8/3; no development.
R 2. 8/5; no development.
S. 8/15; no development.¹

1914: ♂ *St. alba* (462) (con.)
♀ *T. orientalis* (99).

A 1. 4/12; no development.
A 2. 4/14; broken.
B 1. 4/27; no development (analysis).
B 2. 4/29; analyzed.
C. 5/6; no development.
D. 5-11; no development (cold?).
E. 5-19; no development.
F 1. 6-8; no development.
F 2. 6-10; broken.
G. 6-17; calorimeter.
H. 6-23; calorimeter.
I. 7/5; no development.
J. 7/9; soft shell (calorim.)
K 1. 8/6; analyzed.
K 2. 8/8; analyzed (thin shell).
L. 8-15; analyzed.
M 1. 8/29; no development.
M 2. 8/31; no development.
N 1. 9/11; no development.
N 2. 9/13; 5 day embryo.

Bird injured herself in flight soon after above eggs
were laid; no more eggs during 1914.

(O. R.)

¹ The female noted 9/12 '13 to have a scurvy, scaly-like affection on legs and ear.

TABLE 25.

♂ *T. orientalis* (105); 7/25/10; dead 3-28 '15; 4 yr. 8 mo.♀ *St. alba* (817) (trace of risoria); 11-30 '12; alive 10-9-14; 22½ mo.¹

(For the earlier—mostly unsuccessful—attempts at mating 105 see under "condensed records," already given.)

A 1. 4/28/13 (first egg in life); analysis.	E 1. 7-30; broken 8-2=a 1 to 2 day embryo.
A 2. 4/30/13; analysis.	E 2. 8/1; broken 8-2.
B 1. 5/31; analysis.	F 1. 8/8; no development.
B 2. 6/2; analysis.	F 2. 8-10; no development.
C 1. 6/13; no development.	G 1. 9-10; no development.
C 2. 6/15; no development.	G 2. 9-12; no development.
D. 6/21; soft shell.	H. 9-22; no development.
(Insistent nesting here.)	
	I 1. 10/13; no development.
	I 2. 10/15; no development.

¹ On 7/1/14 the dam (817) was recorded as tubercular; dead 10-9-14; showing tubercular lungs, liver, spleen, and joints. But since the eggs of April and May of the second year produced young, this female (mature at 5 to 6 mo.) can hardly be held responsible for the earlier infertility.

TABLE 25 (continued).

A 1. 1/21/14.	B 1. 2/21; analysis.	H 1. 4/21; analysis.
A 2. 1/23/14.	B 2. 2/23; analysis.	H 2. 4/23; analysis.
C 1. 3/10; no development.		♂ I 1. 4/29; 525; alive 4/1/15.
C 2. 3/12; no development.		♂ I 2. 5/1; 534; alive 4/1/15.
D 1. 3/18; no development.		J 1. 5/13; 4 to 5 day embryo.
D 2. 3/20; no development.		♀ J 2. 5/15; 596; alive 4/1/15.
E 1. 3/27; no development.		K 1. 5/21; no development.
E 2. 3/29; no development.		K 2. 5/23; no development.
F 1. 4/4; no development.		L 1. 6/1; dwarf egg; trace of yolk.
F 2. 4/6; no development.		L 2. 6/3; remainder of above yolk (infertile).
♂ G 1. 4/13; dead (cold); 5/5/14.		M. 6/12; no development. ²
G 2. 4/15; no development.		(O. R.)

² Male 105 with sister (99) from 10/24/14 to 3/20/15, no result.

TABLE 26.

♂ T. orientalis (76); 3/17/07; stolen 8/12/12; 65+ mo.			
♀ T. orientalis (38); (? 1905 or 1906?); (ancestry doubtful, but probably related to ♂ 76) ? mo.			
A. 4/30/09.	92.	dead; (certainly before 12/20/10).	
♂ B 1. 7/12.	93.	dead.	11/24/10. 16 mo. 12 da.
♂ B 2. 7/14.	94.	dead.	10/19/09. 3 mo. 5 da.

♂ T. orientalis (76) as above; uncle; 65+ mo.

♀ T. orientalis (88); 6/23/08-4/23/13; niece; 58 mo.

Mother of 88 = a sister (11) to 76.

♂ A 1. 5/26/10.	101.	escaped.	6/23/12.	25+ mo.
A 2. 5/28/10.	102.	dead; not well fed.		
B 1. 7/13;		no record.		
B 2. 7/15;		3 to 5 day development; probably deserted.		
C 1. 7/19.	102.	dead between 2/17/11-4/30/11.		8 to 9 mo.
♀ C 2. 7/21.	103.	dead.	1/15/11.	5 mo. 24 da.
? D 1. 8/22.	106 ¹ .	dead.	2/10/11.	5 mo. 17 da.
♀ D 2. 8/24.	107.	dead.	2/25/11.	6 mo. 1 da.
E 1. 10/13.	110.	dead (cold?).	11/12/10.	1 mo.
E 2. 10/15.	111.	dead.	11/12/10.	1 mo.
Breeding continued 1911 by O. R.				(F 28)

¹ Autopsy showed only one questionable gonad; large wolffian body, and abnormal kidney.

TABLE 26A.

♂ T. orientalis (40); 4/28/05; uncle; 5/1/13; 72 mo.			
♀ T. orientalis (88); 6/23/08; niece; 4/23/13; 58 mo.			
F 1. 9/17/12;		not tested.	
F 2. 9/19/12;		not tested.	
♀ G 1. 9/28.	840.	dead.	4/5/13. 6 mo. 7 da.
G 2. 9/30.		dead.	10/18/12. 18 da.

These birds together until death of 88 on 4/23/13, but produced no eggs.

(O. R.)

¹ This male was from ♂ 2 × ♀ 2, and thus a brother to the father of ♀ 88.—EDITOR.

TABLE 27.

♂ T. orientalis (76); 3/17/07; stolen 8/12/12; uncle; 65+ mo.				
♀ T. orientalis (88); 6/23/08; 4/23/13; niece; 58 mo.				
♂ A 1. 5/15/11	} one	452.....	dead 5/16/13..... 24 mo.	
♂ A 2. 5/17/11		446.....	dead 2/21/13..... 21 mo. 5 da.	
B 1. 5/29; healthy young killed by foster parents.				
B 2. 5/31; healthy young killed by foster parents.				
♂ and ♀	C 1. 6/10	} one	412♂	dead 3/25/13..... 21 mo. 14 da.
	C 2. 6/12		500♀	alive 1/1/15..... 43+ mo.
♂ and ♀	D 1. 6/24	} one	...♂	dead 7/14/11..... 20 da.
	D 2. 6/26		481♀	alive 1/1/15..... 43+ mo.

TABLE 27 (continued).

E 1. 7/3.....	starved.....	dead 7/29/11.....	24 da	
E 2. 7/5.....	starved.....	dead 7 29 11.....	24 da	
♀ F 1. 7/17.....	} one {	433.....	dead 11 27 13.....	28 mo. 9 da
♀ F 2. 7/19.....		489.....	dead 3 28 13.....	20 mo. 10 da
? ♂ and ? ♂ G 1. 7/25.....	} one {	440? ♂.....	escaped ¹ between 10 24 12 12 1 12.....	16 + mo.
G 2. 7/27.....		424? ♂.....	disappeared 5 1 12.....	10 + mo.
H 1. 8/6.....	428; escaped before 12 1/12.			
♀ H 2. 8/8.....	429.....	alive 1/1/15.....		41 + mo.
♂ I 1. 8/14.....	464.....	alive 1 1 15.....		40½ + mo.
I 2. 8 16.....	444; disappeared before 12 1 12.			
♀ J 1. 8/22.....	454.....	dead 3/24/13.....		19 mo. 2 da.
J 2. 8. 24; (yolkless egg).				
♀ K 1. 9/1.....	475.....	dead 3/23/13.....		18 mo. 22 da.
K 2. 9. 3; drowned at two weeks.				
♂ L 1. 9/14.....	} one {	421.....	dead ² 1 1 15.....	39½ mo.
♂ L 2. 9/16.....		488.....	dead 4 23 13.....	19 mo. 7 da
♀ M 1. 9/26.....	436.....	dead 4/5 13.....		18 mo. 9 da
♀ M 2. 9/28.....	423.....	dead 2/21/13.....		16 mo. 23 da.
N 1. 10/21; not incubated.		O 1. 11 6; not incubated. ³		
N 2. 10/23; not incubated.		O 2. 11/8; not incubated.		(O. R.)

¹ Copulated as ♂; laid no eggs; eggs of *alba* consort absolutely infertile.² The sex-glands certainly abnormal, *no right testis* discernible. The left testis exceedingly small (less than 1 mg.) when bird died of tuberculosis.³ ♂ 76 and ♀ 88 were left together until 4/15 12. Four clutches of 1 egg each were laid 1 6 to 3 10, all on floor and fertility not determined; 4 14-16 another clutch. *Sl. alba* ♂ 224 was then offered, but not accepted. On 9 3 *T. arizonae*, ♂ 40 was given. They then produced only two clutches as shown in table 26A.

CHAPTER VI.

EFFECT OF SEASON OF HATCHING UPON DISTRIBUTION OF FERTILITY AMONG THE OFFSPRING OF AN OVERWORKED PAIR OF JAPANESE TURTLE-DOVES.¹

In earlier chapters the function of fertility has been examined in its relation to sex and to longevity, and with reference to its dependence upon age, seasons, inbreeding, width of cross, and the experimentally induced "overwork." Some later chapters, too, bear in part upon those topics. It is now, however, of interest to inquire whether the reduced fertility or "weakness" of germs is continued into the germs of the next generation, *i.e.*, whether this reduction is of significance in heredity as well as in the individual development. The demonstration of the relation which fertility bears to the development of sex is sufficient definitely to give it a genetic value, but we may now examine more specifically some data that have to do with the question of the continuance in the offspring of the lower and higher levels of fertility which have been seen to correspond to *season*.

In the preceding chapter the continuance of low levels ("mutations") of certain characteristics, which were likewise originally induced by extreme age and inbreeding, have been considered. Near the conclusion of that presentation the inbred family (table 27) which now becomes the subject for special treatment was referred to briefly.

The relationship of the two birds chosen as parents for the family in question, and the earlier performance of these same birds (table 26A) was, for us, a sufficient guarantee that some weak progeny could be secured from this mating at the extreme end of the season; and if a considerable amount of "overwork" could be induced, sufficiently large numbers of young might be secured in a single season to supply material for an additional test—a further comparative test—to learn whether the germs of birds which themselves arose from germs of reduced fertility will in turn reveal reduced fertility;² and whether birds from the same parents, proceeding from stronger, more fertile germs, will in turn form germs of higher developmental power.

The investigation of the fertility of the young of this pair of birds bred in 1911 has supplied a body of very interesting data. It is perhaps still too early to write the complete story of their relative fertility, since some of the family are still alive. It is nevertheless already clear that those birds which developed from the "stronger germs" of the earlier part of the season of 1911 in their turn have produced *germs* of greater developmental power than have been produced by their brothers and sisters hatched from eggs laid later in the season under stress of reproductive overwork.

¹ This chapter was written wholly by the editor, and is based upon a breeding study which was also carried out by him (see next foot-note). The study is based on a mating (table 26) arranged and followed during 1910 by the author.

² An early examination of the author's manuscripts by the editor made it clear that although there was much evidence bearing on this point (of a continuance of reduced fertility from an induced low fertility and an association of weak germs with femaleness), the form of the records would make it difficult or impossible for any one other than the author to present the "whole" of the fertility tests for all of the members of any large family treated in the author's records. It was therefore decided to make of this series of 1911—the series now about to be described—a new and additional test of the matter. By making the records himself, and having this specific point in mind in making the matings for the fertility tests, the editor is able to give a fairly full account of this test case.

In this series, from a single season, there are 19 birds which lived long enough normally to seek expression of their sexuality. They arose from a series of 30 eggs (table 27). They are the result of inbreeding together with "overwork," and (for some of them) late season. All of these factors are seen elsewhere, as well as here, to produce weakened germs. *In this case, moreover, it would seem (1) that developmental power was bestowed upon this family sufficient to produce fully fertile females, but insufficient to produce fully fertile males; (2) that only those females that arose from the stronger earlier germs were possessed of high, full, or complete reproductive power.* In other words, *females only in this family exhibit the function of fertility unreduced; and only those particular females which were obtained from the stronger earlier eggs of an overworked female parent exhibit an unreduced or but slightly reduced fertility; their sisters from the weaker germs of late in the season show less fertility or no fertility.* This differential of fertility for the sexes was an unexpected though probably a significant result.

Perhaps if this situation were stated in terms of Professor Whitman's views on fertility, season, and of the relation the sexes bear to each other it would be simply this: The mating of related birds results in weakened offspring; the function of fertility suffers with other functions—it too is weakened; the effects of overwork and of lateness of season progressively accentuate this weakness. It would seem from the data of this chapter, that where fertility is much reduced *from these sources*,³ fully equipped females though not complete males⁴ may be produced; and that this may possibly have a bearing on the author's thesis that "the male goes (and must go) further in development than does the female"; or, again (if the present data were sufficient for a generalization), where developmental energy, from such a reason, is not of normal strength, females may be produced without obvious defect, but males then produced may bear obvious defect.

It may seem to some that there is here a contradiction of certain aspects of the principle of "reduced fertility in proportion to width of cross" which has been established in earlier chapters; for it was there found that the crosses of most widely separated species yield only or almost exclusively males, and that fertility is usually reduced in proportion to the width of crosses. In those cases too the individuals with rudimentary sex-glands were the occasional *females*, not the males.⁵ All is made clear, however, when one distinguishes, as has been done in Chapter III, between the two very different means of reducing the "fertility" of germs. In obtaining males from the "wide crosses," the "strongest" germs of the birds are utilized; and apparently there is here, as in the crossing of varieties, additional "strength" obtained by the mere act of crossing. The reduction of fertility which pertains to such wide crosses rests upon some "incompatibility," or lack of coördination, of the two fused plasms, while the reduced "fertility" which is patent in the data now under consideration rests certainly upon a very different basis—upon "weakness" in fact. Here parents begin by supplying germs at once "weakened" by a union with a related (inbred) germ; in addition, too rapid work at

³ That is, inbreeding and lateness of season associated with overwork.

⁴ Recent quantitative studies on sex in pigeons by the editor go very far toward establishing the proposition that males are not only less likely to be produced, under the extreme conditions referred to here, but those which do arise are less "masculine" than are other males.

⁵ Note that in the family under consideration, 1 male, from the end of the season had only a single testicle.

egg-production further "weakens" the germs; and late season brings, in some way, a still further "weakness." It is from this sort of "reduced fertility"—a fertility founded upon weakness—that females have been obtained which are more adequate, more complete (in respect to fertility) than their brothers. Such weakness of developmental energy may produce, according to these data, a relatively perfect individual of the "weaker sex," but not a perfect individual of the sex which must go "further in development than the female."⁶

It is largely because of the obvious bearing which these data have upon Whitman's conception of the relation which the sexes bear to fertility, that advantage was taken of this large family to make a thorough study of the fertility of its members. Some of the same sort of thing may be found in many of the families bred by Professor Whitman himself, and he was plainly convinced that the weak fertility of a germ tends to be reproduced as weak fertility, and as weakness of other sorts, into the germs of the next generation. But an early examination of his data, together with some indications and references to this pair (which he had mated in 1910; see table 26), convinced the editor that the parents of this particular family should be left mated, the greatest possible number of offspring secured, and the fertility of these adequately studied. This chapter is, then, the result of such an effort.

Three means are used in the presentation of the results: (1) a very general textual statement; (2) a condensed table, followed by the more important individual tables which give a better and more detailed idea of the situation; (3) a very short and inclusive history (in smaller type) of the essential facts which a critical survey of the evidence would require. It will be noted that an attempt has been made to test the fertility of these young with each other and with another species (*St. alba*) with which *T. orientalis* is normally quite fertile.

An examination of the condensed tabulation (table 28) shows that all of the 7 males were deficient *as males*; 3 had opportunity to mate (after sexual maturity, of course) and failed; 3 others mated, copulated with egg-laying females, normally fully fertile with this species, and proved in all of many tests absolutely infertile. One male (421) which arose late in the season, but from a clutch of eggs which threw 2 *males*, was very weakly fertile. When a little less than a year old (with *St. alba*) this male proved practically infertile; 4 eggs were produced; 2 showed no trace of development, the other 2 gave rise to 2-day and 4-day embryos. During a second year half of the eggs tested with another *alba* were hatched, though half of the young died very early (see table 31). In his third year, with still another *St. alba*, this male is responsible for 20 absolutely infertile eggs and no fertile ones.

On the other hand, 2 females, the *first* and *third*, proved to be highly fertile, the first (500), with two different *St. alba* males, the third (433) with an inbred "mutant" *T. orientalis*⁷ (108). The second female (481) of the season has not yet been properly tested as to fertility, largely because of her low and peculiar fecundity and her abnormal eggs and egg-laying instincts. It turns out that the 4 of her eggs properly tested were laid within 3 months of the death by tuberculosis of her male (*St. alba*) consort. The infertility of these 4 eggs is, therefore, of little or uncertain significance (see table 29). This female is most remarkable for having

⁶ See Chapters V-VII, Volume I.

⁷ This pair gave rise to the series of end-of-the-season "mutants" described and figured in the preceding chapter.

laid 15 clutches of eggs, with 1 egg only in a clutch! She has never laid a clutch of 2 eggs, and no other known member of her species has a comparable history. The fourth female (489) was not very thoroughly tested. During her 20 months of life she laid no eggs, or only one at most, and was thus certainly less *fecund* than the 3 females which had preceded her. The fifth female (429) when well tested showed, both with *orientalis* and with *alba*, a very low percentage of fertility, the percentage, too, being higher with the former than with the latter. The sixth, seventh, eighth, and ninth females, the last of the year, all had sufficient opportunities to mate without doing so. The length of life of these birds was less than that of birds from the first of the season, but females 500 and 433 (first and third of the season) had each produced many young before they had reached the shortest of the shorter life-terms of these end-of-the-season females.

For a closer and more critical view of this situation the series of tables and the summarized complete individual histories which follow may be consulted. Many questions will arise, the answer to which can be found in definite dates and details presented there.

FERTILITY OF FEMALES OF THE SERIES.

The females of the series will be considered first. It has already been pointed out that the most fertile member of this family was female No. 500, which is at the same time the first or earliest of the females of the list. On April 13, 1912, this bird laid her first eggs (only 10 months old) before her removal from her winter quarters with other *T. orientalis*. On April 24, 1912, she was placed with a *St. alba* that proved to be a female; they seem to have mated and each soon laid (4) eggs. Neither of these first eggs had opportunity to be fertilized. These and several others from the series of 1912 and 1913 were used for other studies. Late in May of her first breeding season she was given a male *St. alba*; from this pair 21 additional eggs were obtained during the season. The fertility of 15 of these was tested. The fourth, fourteenth, and sixteenth of the series were infertile. 12 young hatched and practically all are alive at the end of 3 years (table 43).

During 1913 the same pair produced 28 eggs and 15 young, 3 eggs again testing infertile. Her mate died of tuberculosis November 24, 1913. A new *St. alba* (nearly pure) mate was given April 1914. From this pair (till March 20, 1915) 50 eggs have been obtained. All except 4 broken ones have been tested; 2 of these broken ones are known to have contained live embryos, and 2 showed no development whatever. These latter were the twenty-first and twenty-third eggs of the season (August 7 and August 22). Two full-term embryos died from faulty incubation, and 1 egg showed only a trace of development. Nearly all of the young of 1913 and 1914 are also still alive (tables 43 and 44) at the time this is written. It is clear, therefore, that this female—the first female of the season—was by far the most fertile of the entire family to which she belonged. Her very long breeding record is placed in the following chapter because of its bearing on subjects discussed there.

The short earlier statement, together with table 29, supply all that it is necessary to present concerning No. 481, the second female of the season. Likewise the very full treatment accorded in the preceding chapter to the offspring of the third female (No. 433) sufficiently presents the degree of fertility of this bird. It was there noted (table 20) that even with a weakened "mutant" inbred male

(108), half of her eggs were hatched, and several other eggs showed well-developed embryos. The fourth female (489) lived 20 months and laid no eggs.

The fifth female (429) was left with other male and female *T. orientalis* until 15 months old without indication of desire to mate. Early in May 1913, however, this bird while unmated laid her first eggs. She was thereafter mated with a *St. alba* (672); the mating proved very infertile. She was remated September 30, 1913, to learn whether she would prove more fertile with a male (69) of her own species. It will be noted that very many of her eggs had peculiar shells—roughened with calcareous nodules, or were soft and defective. That maternal instincts were also awry in this female is shown by habitual egg-laying from the perch. A comparison of the data of the two matings (table 30) shows that when female 429 was mated with a male of her own species she was very plainly more fertile than when mated with *St. alba*.⁸ From this latter mating only one egg of 17 tested showed any trace of development; this one hatched. The mating with one of her own species, though a brother to her father, yielded eggs showing some development in 7 of the 9 tests; 2 of these developed near to hatching. The considerable numbers of untested eggs, usually broken or defective, were used in other studies.

The sixth female (454) lived for 19 months, and although constantly with males of her own kind she laid no eggs and showed no signs of mating. The seventh (475) has a similar history. The eighth and ninth females had a slightly shorter term of life, but like the preceding remained with their mature brothers without producing eggs, and without showing any indication of their sex, or of desire to mate.

FERTILITY OF MALES OF THE SERIES.

Three of the 7 known males showed no signs of mating and never won mates; this evident deficiency of Nos. 452, 412, and 488 is all that was learned of them. It has been noted that 5 of the known females show a similar history. It may here be added that 3 members of this family escaped or disappeared without having revealed their sex by means of eggs or mating behavior. Successful tests were made of the fertility of 4 males; 3 proved absolutely infertile. Reference to these tests will be made after the single case of partial fertility is described.

The original data on the fertility of male 421 is given in table 31. The bird was tested with 3 different females. He mated when only a year old, but at this time (1912) only the slightest fertility was in evidence. Even in the earlier months of 1913 fertility was still too low. Finally, all of the 20 eggs from the mating of 1914 were absolutely infertile, though the birds were frequently seen to copulate. On July 16 it was decided to replace this male with a *St. alba* (715) to see whether the complete infertility might be traceable in part to the female. That this was not so is shown by the record (table 32), from which it appears that notwithstanding the lateness of the season and the previous overwork, this female was still fairly fertile with the new male. There can therefore be no doubt whatever that "weak sperm" of male 421 is responsible⁹ for the uniform lack of development in the earlier part of the season. No. 421 acquired his weakness by inbreeding and through his origin from an egg produced late in the season, under conditions

⁸ Possibly part or much of this difference in fertility for two successive years may be due to ageing; it is unsafe to press such comparisons very far.

⁹ This male died January 1915 (very tubercular); it had no right testis discoverable at autopsy; a diminutive left testis; a very large tubercle involving whole of spleen, and possibly the whole of another left gonad.

of "crowded reproduction." The *St. alba* male (715), which was tested with the above female, was produced under similar seasonal conditions as the inadequate male 421; but the former was not an inbred. When bred to his sister a considerable proportion of the eggs developed ¹⁰ (table 32). The trace of fertility found in 421 is, however, the only trace that will be found among the 7 known males of the series.

Male 464 proved wholly infertile in 6 successive tests with a *St. alba*, as is shown in detail in table 33. Similarly male 440 was as completely infertile with *St. alba* in 13 successive tests (table 34). The complete infertility (in 5 tests) of the male last to be considered (446) is recorded in table 35. In this case the female (*St. alba*) used in the cross was tested immediately before and immediately after her infertile union with 446. The earlier mating was with a *T. orientalis* male, a brother to 446, but from the previous year; in the later mating a male *St. alba* was used. In both of these matings the tests proved fully fertile. Male 446 was therefore wholly responsible for the 5 infertile eggs produced during his mating period.

It will be of interest to present here the record for 1913 of the female used in the three matings just described in connection with the fertility tests of male 446. In the first place, this will better show how completely fertile was the female with which that bird was so completely infertile; and secondly, the data will be seen to reflect, in the offspring of overworked *St. alba* parents, some of the features which until now we have considered in *T. orientalis* only.

The data recorded in table 36 bring out the following points:

(1) The fertility of 31 eggs was tested. The first 22 of these were fully fertile; the twenty-third and twenty-fourth were able to reach full embryonic development but unable to hatch; the "first" egg of the following clutch was fully fertile, while its mate produced only a four-day embryo (imperfect shell may or may not have caused this). The following clutch contained an infertile and a broken egg; the next an infertile and a fully fertile egg which produced a bird, probably weak; it died 16 days after hatching, and presented at that time no well-defined sex-glands. The last of the 31 eggs tested for fertility produced a 6- to 8-day embryo. A total of 51 eggs were produced during the season. Those not accounted for in this table were used in other work (chemical analysis).

(2) Seven of 16 eggs laid before July 1 and incubated, produced males; 3 produced females. After July 1, 3 males and 4 females were hatched. Though these numbers are not large, they are in both cases similar to those of the previous year (table 35).

(3) The two clutches which immediately precede the first unhatchable clutch both produced males from the first and females from the second egg.

(4) The sex-glands of a 1-month-old bird from the end of the season (September 23) were largely or wholly undeveloped.

(5) Though the data for length of life are not yet complete, many birds being still alive, it is clear that the later eggs of the season gave rise to birds of shorter life-terms. The "seasons" in the previous year (table 35) also bear a similar relation to longevity in addition to sex, as noted above.

(6) These results obtain from a mating that approximates to a mating of two individuals of the same species, the female being a $\frac{3}{4}$ *alba* \times $\frac{1}{4}$ *risoria* hybrid. It is evident that the great decrease in fertility at the end of 1913 was largely due to reproductive "overwork," though the predominance of males at the beginning of the season and the general vitality of the young were possibly somewhat influenced by the slight element of crossing which is also involved.

¹⁰ This second male also died of tuberculosis on March 1, 1915.

*Condensed and consecutive record of matings made to test fertility of offspring of this family.*¹¹

♂ 452. 5/16/11-5/16/13; 24 mo.

When a year old this male placed with *St. alba* 409 (also one year old) which had just laid (while unmated) her first clutch of eggs. These birds remained together until September 3, 1912, without mating. Female 409 died November 15, 1912. After September 3, 1912, 452 was placed with *T. orientalis* (2) then at least 15 years old; no result (♀ 2 died November 17, 1912). During the succeeding winter (and spring) of 1912-13 this male was with several *T. orientalis* (including ♀ 475) of similar age but without result.

♂ 446. 5/16/11-2/21/13; 21 mo.

When 1 year old (June 25, 1912) put with *St. alba* female 414 (then nearly 1 year old). Five eggs produced, all infertile; this, with a female that tested very fertile earlier, and also later, in the same season, with *T. orientalis* 101 and with *St. alba* 26, as is fully shown in table 35.

♂ 412. 6/11/11-3/25/13; 21½ mo.

When a year old was placed for a time—probably the whole summer—with female 481 of this series without result. During the winter of 1912-13 (till death) was with a group of *T. orientalis*, probably without securing a mate.

♀ 500. 6/11/11; alive 10/1/14; 40+ mo.

The very considerable data on this bird will not be presented here in full, nor in tabular form (it would require three full-page tables), since these must be presented in a work of our own (O. R.) soon to be published, in which chemical and other aspects of the ova are studied in much detail. To March 20, 1915, she had hatched 59 young, and only 9 infertile eggs have been found. More than 100 eggs have been produced. Nearly all her young are still alive.

♀ 481. 6/25/11; alive 10/1/14; 40+ mo.

The complete record of this bird is given in table 29.

♀ 433. 7/18/11-11/27/13; 28 mo.

This record is completely given in table 20.

♀ 489. 7/16/11-3/28/13; 20 mo. 20 da.

When 1 year old this bird was put, for about 6 months, with *T. orientalis* 481; probably with no result. It was at first thought that these birds were mated (in general pen) before being given a separate cage, and thought too that 489 had laid an egg; this probably wrong. From November 1912, till death, March 28, 1913, with several *T. orientalis* males without result. This bird was therefore by no means the equal of her sisters 500 and 433 in fecundity nor in desire to mate.

? ♂ 440. 7/26/11; disappeared 10/24/12-12/1/12; 16+ mo.

The short mating history of this male is presented in table 34. Sex known only from behavior.

? ♂ 424. 7/26/11; disappeared before 5/1/12; 10+ mo.

428. 8/6/11; escaped before 12/1/12; 16+ mo.

For 4 months (after a year old) this bird had opportunity to mate with both male and female *T. orientalis* without doing so. Its escape prevented the ascertainment of its sex.

♀ 429. 8/8/11; alive 1/1/15; 41+ mo.

During summer, autumn, and winter of 1912 with two brothers—412 (until January) and 488—without eggs and with no indications of mating. On May 7, 1913 (mated to *St. alba* 672) she began laying eggs, nearly all of which were infertile; during the following year laid mostly clutches of one egg each (infertile); breeding record in table 30.

♂ 464. 8/14/11; alive 10/1/14; 38+ mo.

When a year old this bird was kept for about 6 months with a sister female 436 without result. *St. alba* female 892 was given April 30, 1913. Table 33 supplies the details of this infertile union, and later failure to mate.

444. 8/16/11; disappeared before 12/1/12; 16 mo.

This bird was kept with some of its brothers and sisters without mating. Its escape left the question of its sex undetermined.

♀ 454. 8/22/11-3/24/13; 19 mo.

Like the preceding, this bird remained with the other sex of its own species without mating.

♀ 475. 9/1/11-3/23/13; 18 mo. 22 da.

This bird was kept with its older brother, 452, from early November 1912 till time of death, with no indication of mating.

♂ 421. 9/15/11-1/1/15; 39½ mo.

The full history is given in table 31. The sex-glands abnormal; probably a single testicle.

♂ 488. 9/15/11-4/23/13; 19 mo.

This bird kept with some of its sisters during its whole life; it did not mate.

♀ 436. 9/26/11-4/5/13; 18 mo.

During the 6 months preceding its death, female 436 was kept with its brother 464 without result.

♀ 423. 9/28/11-2/21/13; 17 mo.

This bird, the last hatched of the series, was continuously with one or more of its brothers without having mated or laid eggs.

¹¹ The birds are here listed in the order of hatching.

SUMMARY.

It is elsewhere shown that the germs of pigeons produced late in the season, particularly when the parents have been made to overwork at reproduction, have lower developmental power than have the earlier produced gametes from the same parents. It is also elsewhere shown that the sex-ratio and the longevity of the young produced from such eggs with lowered developmental strength are modified—more females and a shorter life-term result from such gametes. In this chapter is presented the issue of a thoroughgoing comparative test, made upon a large family of Japanese turtle-doves, which had as its purpose the definition of the limits of fertility of each of the several members of the family, and thus to learn whether those individuals which were themselves developed from germs of different levels of developmental power, according to season, do or do not in their turn show, deliver, or transmit their own particular level of developmental strength or fertility to their own germs.

TABLE 28.—Condensed sketch showing relative fertility of *T. orientalis* offspring, 1911.

Nos. in order of hatching. ¹	Length of life.	Opportunities to mate with <i>T. orientalis</i> .	No. of eggs. ²	Opportunities to mate with <i>St. alba</i> .	No. of eggs.	Fertility.
♂ 452	Dead, 24 mo.....	{ w. very old ♀ (2) .. w. sev. ♀'s, 6 mo. (♀ 475)	0 20	409 (sick), 2 mo....	0	0
♂ 446	Dead, 21 mo.....	w. ♂ 201, 6 mo.....	0	414, 4 mo.....	5	No development.
♂ 412	Dead, 21½ mo.....	w. sev., 6 mo. (481)	0			
♀ 500	Alive, 40+ mo....	{		410, 19 mo..... 767, 7 mo.....	49 30	27 hat.; 6 infertile; 16 not tested 24 yg.; 2 broke w. emb.; 2 infertile; 2 not tested.
♀ 481	Alive, 40+ mo....	{ 421, 3 mo..... ♀ 489, 6 mo..... 412, 5 mo.....	0 0 1	215, 13 mo.....	14	Only 4 (w. alba) tested; all infertile
♀ 433	Dead, 28 mo.....	{ 108, 12 mo..... 69, 4½ mo.....	28 0			12 yg.; 4 emb.; 4 infertile; 8 not tested.
♀ 489	Dead, 20 mo.....	{ w. sev., 4 mo. w. ♀ 481, 6 mo.....	20	672, 2 mo.....	0	
{ ♂ 440 424	Escaped, 16 mo.... Disappeared; 10 mo.			430, 5½ mo.....	16	14 absol. infertile; 2 not tested.
428	Escaped, 16 mo....	{ w. sev., 3 mo. w. sev., 3 mo.				
♀ 429	Alive, 38+ mo....	{		672, 4½ mo.....	24	{ w. <i>St. alba</i> ., 6 not tested; 16 absol. infertile; 1 hatched.
♂ 464	Alive, 38+ mo....	436, 6 mo.....	0	892..... 682.....	10 0	{ w. <i>T. orient.</i> ., 14 not tested; 2 no dev.; 7 emb., 2-14 da. 6 tested; all absol. infertile.
444	Disappeared, 16 mo.	w. sev., 3 mo.				
♀ 454	Dead, 19 mo.....	w. sev., 6 mo.....	0			
♀ 475	Dead, 18 mo.....	w. sev., 6 mo., ♂ 452	0			
♂ 421	Dead, 39½ mo....	{ 481, 3 mo.....	0	602, 10 mo..... 744, 4 mo..... 437, 6 mo.....	11 20 4	{ 4 yg.; 4 no dev.; 3 not tested; 20 absol. infertile. a 2 and a 4 da. emb.; 2 absol. infertile.
♂ 488	Dead, 19 mo.....	w. sev., 6 mo.....	0		0	
♀ 436	Dead, 18 mo.....	464, 6 mo.....	0			
♀ 423	Dead, 16 mo.....	w. sev., 6 mo.....	0			

(O. R.)

¹ Where brackets are placed, the order within the clutch is not known.² That is, eggs by the female of the pair as mated.

The data demonstrate that among these individuals the strongest germs—the germs of highest efficiency in the accomplishment of development—were produced by the earlier birds of the season. The two individuals from the *very first* eggs of the season, and those from the last several eggs of the season, were completely or almost completely infertile. Almost completely fertile birds (females) arose from the early season. There appears in these results, moreover, a higher degree of fertility in the females than in the males. The probable bearing of this fact has been already pointed out. The data indicate, therefore, that the low levels of fertility, attained by experimental means—late season with overwork—are levels which not only influence the sex of offspring as shown elsewhere, but that the function of fertility which is thus forced to new levels tends to propagate itself in inheritance upon such newly formed or enforced levels.

TABLE 29.

♂ 215 *St. alba* 1909–10; 6/14/14; 48+ mo.
 ♂ 412 *T. orientalis*; 6/11/11; 3/15/13; 21½ mo.
 ♀ 481 *T. orientalis*; 6/25/11; alive 10/1/14; 40+ mo.

In summer of 1912 this female was with ♀ 489; winter 1912–13 with brother 412; ♂ 412 died 3/15/13 (unmated).

St. alba ♂ 215 given 5/1/13.

A. 3/20/13; (cold) (first in life).

B. 5/14/13; not incubated.¹

C. 5/23; not incubated.

D. 6/1; not incubated.

E. 6/5/13, from perch and broken.²

F. 8/5; from perch and broken.

G. 8/9–10; from perch and broken.

A. 1/2/14; not incubated.

B. 1/27; not incubated.

C. 3/8; not incubated.

D. 3/16; no trace development.

E. 3/26; no trace development.

F. 4/11; not incubated.

G. 5/2; no development.

H. 5/28; no development.

♂ 715 *St. alba*; 8/28/13; alive 10/1/14; 13+ mo.

This male given 6/16/14, when it was active and fertile. On 7/16 (unmated), removed, and her brother (421) given; no result; ♂ 421 died 1/1/15. (O. R.)

¹ Advantage was taken of the opportunity here offered to study the size relations of the egg-yolks of a female that laid clutches each of a single egg.

² The nesting habits of this bird were never normal. Several of her eggs were slightly broken.

TABLE 30.

♂ *St. alba* (672); about August, 1912 (from dealer); 4/17/14; 21? mo.
 ♀ *T. orientalis* (429); 8/8/11; alive 10/1/14; 3+ yr.

A 1. 5/11/13; first in life; shell roughened with calcareous nodules.

A 2. 5/12/13; soft shell.

B 1. 5/27; from perch; broken.

B 2. 5/29; not tested.

C. 6/6–7; from perch; broken.

D 1. 6/14; no development.

D 2. 6/16; no development.

E 1. 6/22; from perch; broken.

E 2. 6/24; no development.

F 1. 6/30; no development.

F 2. 7/2; no development.

G 1. 7/10; from perch; broken.

G 2. 7/12; no development.

H 1. 7/18; from perch; broken.

♀ H 2. 7/20; white; 714; dead 11/26/13; 4 mo. 6 da.

I. 7/26/13 (bird confined) no development.

J 1. 8/4; no development.

J 2. 8/6; no development.

K. 8/13; no development.

L. 8/16 or 17; from perch, broken.

M 1. 8/23; no development.

M 2. 8/25; no development.

N 1. 9/3; no development.

N 2. 9/5; on ground, no development.

O 1. 9/13; no development.

O 2. 9/15; no development.

(O. R.)

TABLE 30 (continued).

♂ 69 *T. orientalis*; 7/17 '06; alive 10/1/14; 8+ years. (given 9/30/13).

A 1. 3/16/14; not tested.	I. 6/4/14; not tested.
A 2. 3/18/14; not tested.	J. 6/15/14; not tested.
B. 3/25; imperfect shell; 4 day embryo.	K. 6/23; not tested.
C 1. 4/6; imperfect shell; 5 to 6 day embryo.	L. 7/14; soft shell; not tested.
C 2. 4/8; from perch; broken.	M. 7/27; not tested.
D. 4/19; imperfect shell; 8 to 9 day embryo.	N. 8/12; cracked; 10 day abnormal embryo.
E. 4/27; imperfect shell; 3 day embryo.	O. 8/25; imperfect shell; cracked; live 3 day embryo.
F 1. 5/6; 13 day abnormal embryo.	P 1. 9/4; not tested.
F 2. 5/8; not tested.	P 2. 9/6; not tested.
G. 5/18; no development.	Q 1. 9/19; not tested.
H. 5/29; no development.	Q 2. 9/21; not tested.
	R. 10/4/14; not tested.

(O. R.)

TABLE 31.

♂ *T. orientalis* (421); 9/15/11; dead 1/1/15; 29½ mo.♀ *St. hybrid* (437); white (¾ alba, ¼ risoria); early 1911; 11/23/12; 18 mo.

This pair put together 4/24/12; ♀ had already laid 2 clutches; first in life.

C 1. 6/30/12 } one 2 day embryo; other a 4 day embryo.	D 1. 7/13; no development.
C 2. 7/2/12 }	D 2. 7/15; no development.

♀ 602 *St. alba* from dealer 1/31/13; 3/8/14; 1½ yr.(?)

♀ was 4 to 8 mo. old when bought. Purity? This pair together 5/19/13.

I. 5/23/13; broken.	
J 1. 7/3; no development.	
J 2. 7/5; no development.	
♀ L 1. 7/27.....dark.....713.....dead 8/17/14.....12½ mo.	
L 2. 7/29.....dark.....dead 8/14/13.....16 da.	
M 1. 8/9; egg stolen.	
M 2. 8/11; egg stolen.	
♀ N 1. 8/24.....dark.....752.....dead 12/17/13.....3 mo., 24 da.	
♂ N 2. 8/26.....dark.....768.....alive 8/1/14.....11+ mo.	
O. 9/11; no development.	

♀ 744 *St. hybrid* ¾ (or nearly) alba, ¼ risoria; 3/3/13; alive 8/1/14; 17+ mo.

This ♀ given early 1914.

A 1. 4/21/14; no development.	E 1. 5/26; no development.	I 1. 6/30; no development.
A 2. 4/23/14; no development.	E 2. 5/28; no development.	I 2. 7/2; no development.
(A 1. First egg in life.)		
B 1. 4/29; no development.	F 1. 6/3; no development.	J 1. 7/11; no development.
B 2. 5/1; no development.	F 2. 6/5; no development.	J 2. 7/13; no development.
C 1. 5/7; no development.	G 1. 6/14; no development.	
C 2. 5/9; no development.	G 2. 6/16; no development.	
D 1. 5/16; no development.	H 1. 6/22; no development.	
D 2. 5/18; no development.	H 2. 6/24; no development.	

(O. R.)

TABLE 32.

♂ 715 (7/8 alba); brother; 8/28/13; dead 3/17/15; 19 mo.

♀ 744 (7/8 alba); sister; same as preceding table.

K 1. 7/22/14; 2 day embryo.	
♀ K 2. 7/24/14.....white.....60.....alive 9/15/14.	
L 1. 7/29.....white.....33.....alive 9/15/14.	
L 2. 7/31; 3 day embryo.	
? ♀ M 1. 8/5; pipped; failed to hatch.	
M 2. 8/7; slightly broken; some development.	
N 1. 8/14.....white.....alive 9/15/14.	
N 2. 8/16.....white.....alive 9/15/14.	
O. 9/19; no development.	

(O. R.)

INHERITANCE, FERTILITY, AND SEX IN PIGEONS.

TABLE 33.

♂ *T. orientalis* (464); inbred; 8/18/11; alive 10/1/14; 3+ yr.

♀ White (892); 11/1/12; 4/30/14; 1 yr. 5 mo.

♀ 892 = $\frac{1}{2}$ *alba* (or nearly) and $\frac{1}{2}$ blond. First clutch laid while mated with a ♀ *alba*.

A. 4 25/13 (first in life); not incubated; (♀ mated with ♀).

B 1. 5/26/13; not tested.

B 2. 5/28/13; not tested.

C 1. 6/22; no development.¹

C 2. 6/24; no development.

D 1. 7/18; no development.

D 2. 7/20; no development.

E 1. 8/23; no development.

E 2. 8/25; no development.

F 1. 11/28; broken.

F 2. 11/30; not incubated.

♀ killed 4/30/14; tuberculosis.

(O. R.)

¹ These birds were rather too young for fertility to be at its greatest height in either. But the male was a weakened inbred from an egg produced rather late in the season from an overworked pair. The female of the above pair became tubercular, probably after most or all of the above eggs were laid. During the season of 1914 this male was kept with a mature female *St. alba* (682) without any eggs whatever being produced. Thus we see another evidence of the weakness of this male when in his third year.

TABLE 34.

440 ♂ *T. orientalis* (inbred); 7/26/11; disappeared 10/24/12 to 12/1/12; 16+ mo.430 ♀ White = $\frac{2}{3}$ *alba*, $\frac{1}{3}$ risoria; 8/16/11; 2/2/13; 1½ yr.

Put together 4/17/12.

It is possible, but hardly probable, that this female had laid 1 or 2 pairs of eggs during the preceding winter.

A 1. 7/4/12; not tested.

A 2. 7/6/12; not tested.

B 1. 7/13; no development.

B 2. 7/15; no development.

C 1. 7/23; no development.

C 2. 7/25; no development.

D 1. 8/1; no development.

D 2. 8/3; no development.

E 1. 8/10; no development.

E 2. 8/12; no development.

F. 8/19; no development.

(No second egg.)

G 1. 8/31; no development.

G 2. 9/2; no development.

H 1. 9/12; no development.

H 2. 9/14; no development.

(O. R.)

TABLE 35.

♂ 101 *T. orientalis*; 5/26/10 (inbred); escaped 6/23/12; 25+ mo.♂ 446 *T. orientalis*; 5/16/11 (inbred); 2/21/13; 21 mo. 5 da.♂ 26 *St. alba* ($\frac{2}{3}$ *alba*, $\frac{1}{3}$ risoria); 4/17/14; 30 to 96 mo.♀ 414 *St. alba* hybrid; 8/6/11; 3/17/14; 31 mo. 11 da.

From 4/24/12 to 6/23/12 *T. orientalis* No. 101 was used as male parent; 6/25 to 10/11/12 *T. orientalis* 446, a younger brother to 101, was used. With ♂ 446 it will be noted that this female was quite infertile. With the more mature brother all her eggs (4) developed; two of these whose sex is known were males. Later in the season this female (*St. alba* hybrid) mated to a *St. alba* produced mostly fertile eggs—4 of 5 tested—and 3 young from this season and mating were females; a fourth young was probably a male.

♂ 26 has not a perfectly clear history; is probably a pure *St. alba*, about three years old; but possibly he is a $\frac{2}{3}$ *alba*, $\frac{1}{3}$ risoria hatched in 1906. Very pugnacious.

♀ 414 = a $\frac{2}{3}$ *alba*, $\frac{1}{3}$ risoria. In breeding behavior these two birds resemble two pure *alba* (all of their 27 young, 1913 to 1914, were white).

♂ 101 *T. orientalis* is a brother (from 1910) to ♂ 446.

A 1. 6/2/12; not tested.

A 2. 6/4/12; not tested.

B 1. 6/11.....dark.....822.....stolen summer 1912.

B 2. 6/13.....dark.....dead 6/27/12 (not fed).

♂ C 1. 6/20.....dark.....846.....alive 4/1/15.....33+ mo.

♂ C 2. 6/22.....dark.....851.....alive 4/1/15.....33+ mo.

♂ 446 *T. orientalis*.

D. 7/4/12; no development.

E 1. 7/29; no development.

E 2. 7/31; no development.

F 1. 8/22; no development.

F 2. 8/24; no development.

♂ 26 *St. alba*.

G 1. 10/22; not tested.

G 2. 10/24; not tested.

♀ H 1. 11/1.....white.....892.....dead 4/30/14.....18 mo.

? ♂ H 2. 11/3.....white.....11/29/12 (cold).

I. 11/16; developed only a "blood circle."

♀ J 1. 11/28.....white.....838.....dead 12/20/13.....12 mo. 23 da.

♀ J 2. 11/20.....white.....817.....dead 10/9/14.....22 mo. 9 da.

(O. R.)

TABLE 36.

♂ St. alba ($\frac{3}{4}$ alba, $\frac{1}{4}$ risoria of 1906, or pure alba) (26); 1906 (?); 4/17/14; 30 to 96 mo.			
♀ St. alba hybrid ($\frac{3}{4}$ alba, $\frac{1}{4}$ ris.) (414); 8/6/11; 3/17/14; 19 mo.			
♂ and ♀ E 1. 3/2/13}	744 ♀	alive 1/15/17	47+ mo.
E 2. 3/4/13}	751 ♂	dead 4/8/14	13 mo. 4 da.
♂ F 1. 3/13	706	dead 4/6/14	12 mo. 23 da.
F 2. 3/15; partly helped from shell at 16 days, failed.			
♂ G 1. 3/22	726	(killed with gonad extract) 10/14/14.	
♂ G 2. 3/24	734	dead 2/7/14	10 mo. 13 da.
J 1. 5/6; fertile; killed.			
J 2. 5/8; fertile; killed.			
♀ L 1. 5/29	708	dead 8/9/16	38 mo. 10 da.
L 2. 5/31	777	disappeared 7/3/13-2/11/14.	
♂ M 1. 6/6	759	alive 1/15/17	43+ mo.
♂ M 2. 6/8	765	dead 4/12/16	35 mo. 4 da.
N 1. 6/14; not fed; dead 7/16/13.			
N 2. 6/16; not fed; dead 7/15/13.			
♂ and ♀ O 1. 6/22}	767 ♂	dead 9/27/16	39 mo. 4 da.
O 2. 6/24}	722 ♀	dead 4/9/15	21 mo. 16 da.
♀ P 1. 7/1	736	dead 4/3/15	21 mo. 12 da.
♀ P 2. 7/3	794	dead 9/29/14	14 mo. 26 da.
♂ Q 1. 7/9	702	dead 6/27/14	11 mo. 18 da.
Q 2. 7/11; (poor care?); dead 8/8/13.			
♂ R 1. 7/17	740	dead 9/14/16	37 mo. 27 da.
♀ R 2. 7/19	775	dead 2/10/15	10 mo.
V 1. 8/20; incubation 17 days; ¹ partly opened, alive; died few hours, very small (1.80 g.), size of 12 day embryo.			
V 2. 8/22; incubation 16+ days; not pipped, but probably full-term embryo.			
♂ W 1. 8/28	715	dead 3/17/15	19 mo.
W 2. 8/30; imperfect shell; 4 day embryo.			
X 1. 9/12; no development.			
X 2. 9/14; broken.			
Y 1. 9/21; no development.			
Y 2. 9/23; hatched, starved (?); dead 10/23/13, but sex not evident in this 1 mo. old bird!			
Z. 10/8/13; 6 to 8 day embryo.			

(O. R.)

¹ This egg should have hatched at 15 days.

CHAPTER VII.

CROSSES OF JAPANESE TURTLE DOVES WITH BLOND AND WHITE RING-DOVES.¹

The considerable number of tables presented here will serve in general for reference in connection with the condensed account of fertility and sex as given in Chapter II. More particularly, they offer: (1) an opportunity to compare crosses which are intermediate to the "distantly related and the closely related" forms of Chapter IV; (2) they show again the effects of season and overwork on fertility, longevity and sex; and (3) they present the following additional features not hitherto considered:

(A) The good effects of crossing related genera as seen in (a) the long term of life of the offspring; (b) the development of all, or nearly all, of the eggs; (c) the predominance of males from the eggs of the spring and early summer and from "uncrowded clutches" generally.

(B) It will be seen (a) that the two eggs of the clutch of the pure females have different sex tendencies, and (b) that there is some evidence that unpaired eggs (*i. e.*, eggs from clutches of one egg only) apparently have stronger sex tendency than have the paired eggs, in that they are more *independent* of season and overwork, in their production of sex, than are the paired eggs.

(C) The fertility of hybrids from these related genera present the following situation: (a) The hybrids crossed *inter se* or with their parent species are usually less fertile than was the original cross, their young live less long, and the sex of the offspring is probably less dependent upon season and overwork, and certainly bears little or no relation to the order of the eggs in the clutch; (b) eggs from matings of complex hybrids are probably more fertile than from matings of F_1 *inter se*, or from F_1 with the parent species; the term of life is probably also longer than from that cross, though this term is shorter than that for the F_1 individuals themselves.

(D) The further breeding of the F_1 hybrids and also of complex hybrids, produced a high percentage of (a) abnormal young, and (b) of *hermaphrodites*.

(E) The crosses of *St. alba* and of *St. risoria* with *T. orientalis* show that color is here a sex-limited character.

¹ The text of this chapter was written by the editor; nearly all of the tabulated data are those of the author.

EXPLANATION OF PLATE 8.

A. Adult female white ring-dove, *Streptopelia alba*. $\times 0.5$. Rowland del., Sept. 1914.

The ring has been over-emphasized in its depth of color.—Ed.

B. Adult female blond ring-dove, *Streptopelia risoria*. $\times 0.5$. Hayashi del.

View of entire bird. The three separate feathers are (from left to right) the extreme upper, middle, and lower parts of the ring or neck-mark. The general color could be described as a pale fawn, or isabelline, which becomes lighter on the throat, and fades out towards and around the vent, passing imperceptibly into the white of the under tail-coverts. The black ring is sometimes narrower at its middle on the back of the neck than at the ends. This fact, together with the complete interruption of the ring on the back of the neck in the first plumage (by which it is broken into two portions, one on each side of the neck, beginning a little below and behind the ear-coverts and growing narrower backward), suggests that the half-ring has arisen by the extension of two spots like those seen in the mourning-dove. This ring is creamy-white in the "Vienna white dove" (*St. alba*). It is often reduced to a mere shadow, or wholly absent, in the first plumage.



A



B

A. Adult female white ring-dove, *Streptopelia alba*. $\times 0.5$. Rowland del., Sept. 1914.
 B. Adult female blond ring-dove, *Streptopelia risoria*. $\times 0.5$. Hayashi del.



Adult female, *Streptopelia alba* × *Turtur orientalis*. Hybrid (10). From egg 7-16-07. × 0.9. Hayashi del., Apr. 1908.

A. Entire bird, showing that color is not a pure "white." Dorsal coverts and feathers of neck-mark show brownish pigment.

B. Under side of outer (left) tail-feather. That part of proximal feather which is black in *orientalis* and in *risoria* here bears a rather pale brown or isabelline. × 0.8.

C. Upper side of the same feather. × 0.8.

D. One of the more pigmented feathers of the neck-mark. Natural size.



Adult male, *Turtur orientalis* × *Streptopelia alba*. Hybrid (15). From egg 7-30-08. × 0.8. Rowland del., Aug. 1914.
Compare the lighter color of this bird with the darker shade of a half-sister, plate 11.



Adult female, *Turtur orientalis* × *Streptopelia alba*. Hybrid (27). From egg 6-16-09. × 0.8. Rowland del., Aug. 1914.
The females of this cross are perceptibly, but not very strikingly, darker than their brothers. Compare with plate 10.

The tabulations presenting these breeding data fall more or less naturally into four groups. Those four groups will be considered after a survey of the sex-limited phenomena involved in these crosses. This order of treatment will permit the reader to become more quickly familiar with the appearance and general characteristics of the forms crossed and of the resulting hybrids.

The Japanese turtle-dove has already been seen in color in pl. 1; the white ring-dove (*St. alba*) and the blond ring-dove (*St. risoria*) are here shown in pl. 8. It will be observed that these three species are markedly different and distinct in color and color-pattern.

SEX-LIMITED INHERITANCE OF COLOR IN BLOND AND WHITE RING DOVES CROSSED WITH JAPANESE TURTLE-DOVES.

Reciprocal Crosses of St. alba and T. orientalis.—The offspring of a *St. alba* male mated to a *T. orientalis* female are of two colors. One of these colors is quite dark (males), though not as dark as that of the female parent. It is nearly like the male of the reciprocal cross which is shown in color in pl. 10. The other color is "almost white." Indeed, unless the bird and its feathers are given more than a glance, one may overlook the traces of brownish pigment present in most body feathers, and the more than a trace of brown in the neck-mark and in the under proximal parts of the rectrices. These birds, which will be spoken of as "white," are, therefore, not pure white, as is their father.² The bird figured in pl. 9 will demonstrate, however, that this group is most sharply differentiated from the dark members of this fraternity. Text-fig. 1 gives a photographic view of a brother and sister.

Matings of these two species, with the white ring as father, have yielded 59 dark and 43 white offspring. The sex of 45 of the dark birds is known;³ they were males in every case. The sex of 40 of the 43 white birds is known; they were females in every case. The records are available in tables 23, 24, 42, 43, and 44. It is reasonably clear, therefore, that in this cross the white color of the father is exhibited by all of his daughters and by none of his sons.

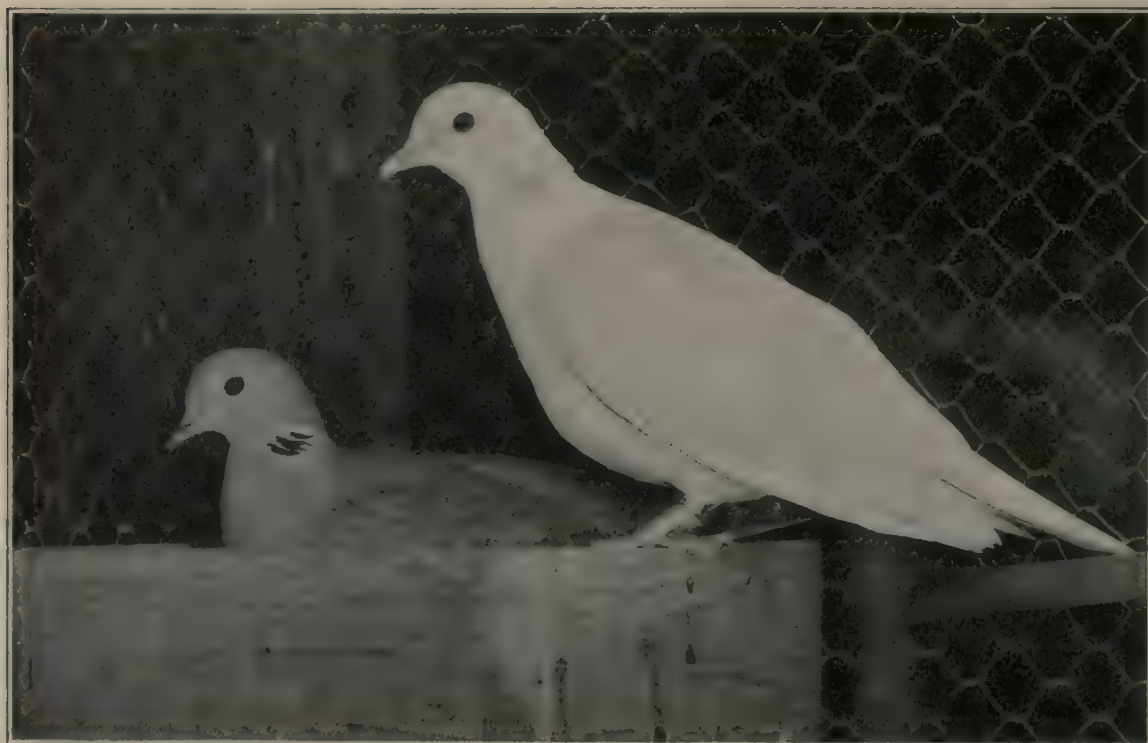
When, however, the white ring is used as the female of the cross no white offspring are produced. Sons and daughters are both of dark color. But close examination of these young shows there is a slight color difference between the males and the females. In this case the males are perceptibly lighter in color; the females a trace darker. The difference is made clear in pls. 10 and 11, which reproduce the colors of the male and female respectively. From this cross 34 males and 39 females were obtained. Tables 37 to 41 (with 25, 31, 35) present the whole of these data.

Reciprocal Crosses of St. risoria and T. orientalis.—Blond ring-dove males mated to Japanese turtle females produce young of two colors. These bear a relation to the parental colors somewhat similar to that described above for the white ring \times Japanese cross. Darker and lighter forms appear; the dark birds are all, or

² Neither of these two colors therefore represents a "pure" or complete segregation of a parental color.

³ About 10 other dark birds of this series are alive, but their sex is not yet fully tested. Where an interrogation point precedes the sex-sign in the tables referred to above, this point is intended to indicate that the sex of the bird has not yet been positively learned. Where a question mark is not followed by a sex-sign the mark usually indicates that the sex-glands of the bird were abnormal, and invites attention to a further statement concerning it. (All of the ten dark birds later proved to be males.)

nearly all, males; for example, 7 of the 8 birds listed as dark in table 47 proved to be males; the 3 birds there listed as of light color were females; but 1 female was stated to be of dark color. The data are incomplete, but it would seem that in this cross an occasional female may exhibit the dark color which is shown by all of the males. The light-colored females are not as light-colored as is the blond-ring parent; but as may be seen in pl. 12, the color, the color-pattern, and particularly the neck-mark, all afford evidence of the strong influence of the Japanese parent.



TEXT-FIGURE 1.—Adult *Streptopelia alba* × *Turtur orientalis* hybrids—male and female (brother and sister; see table 42, under 7 and 5).

The white bird is the female; the dark is the male. The colors contrast strongly and are sex-limited in inheritance.

In a cross of Japanese males and blond ring females the relation of sex and color in the offspring is not quite clear. It is certain that all of the young are relatively dark in color. A male of this series is reproduced in pl. 13. The living

EXPLANATION OF PLATE 12.

Adult male *Streptopelia risoria* × *Turtur orientalis* hybrid (1). From egg 4/23/04 (table 47). Nine-tenths natural size. Hayashi del., May, 1905.

Fig. A. × 1. General coloration and characteristics of the entire bird.

About a dozen filoplumes are seen on the neck-spot—often one to each of the colored feathers. One plucked feather measured 13 mm. in length, its filoplume 14 mm. The latter consists of a slender hair-like shaft, arising close beside the shaft of the feather and bearing at its tip two, three, or four fine diverging barbs (?). Each barb bears irregular short barbules. The whole is white—hence conspicuous on a black background. These filoplumes are single—one for each feather; a few are found outside the spot, but only for a short distance.

Fig. B. × 2. One feather from right side of neck-mark

Fig. C. × 4. Filoplumes of above feather further enlarged.



Fig. A. Adult male. $\times 0.9$. General coloration and characteristics of entire bird, with neck-mark seen from side.
Fig. B. $\times 2$. One feather from right side of neck-mark.
Fig. C. $\times 4$. Filoplumes of above feather further enlarged.



Adult male, *Turtur orientalis* × *Streptopelia risoria*. Hybrid (1). From egg 5-8-04. × 0.8. Hayashi del., Apr. 1905.

This is one of the "dark" variety. Feathers have dark centers and light edges; centers not definitely outlined, they merge gradually into the light edge. Feather-shafts dark. Lower edges of tortils and long coverts darker reddish than are smaller parts of the smaller coverts. Iris red-orange; skin around eye pale with eyelids reddish; beak blackish; feet and legs purplish red. Feathers of breast pale vinous.

forms examined by the editor indicate that, similar to the *orientalis* \times *alba* cross, the females are slightly darker than the males. This situation was not adequately treated by the author, though he has noted that the "juvenal" plumage of the first-hatched female of this series (treated in table 48) was slightly "lighter" in color than her male nest-mate.

Color and Sex in F₂ Ring-Japanese Hybrids.—The very low fertility of the F₁ hybrids, and the weakness, short life and sex-abnormalities which are associated with the few gametes which do begin development, have here prevented a full elucidation of the relation of sex and color in the F₂ generation. The author's limited data bearing on this point are given in tables 49 to 52. The back-crosses with the parent species are far more fertile than are crosses made *inter se*. The very restricted life-terms and the varied abnormalities formed from these crosses afford the best of material for the study of many important problems.⁴

RECIPROCAL CROSSES OF ST. ALBA AND T. ORIENTALIS.

Several of the subjects mentioned in the introductory statement of this chapter can be best examined through a subdivision of the rather extensive breeding data into the four groups into which they can be conveniently classified. Frequent or constant reference to the complete original data as given in the tables will, however, be found quite necessary.

Orientalis male \times *alba female*.—The very complete breeding record of a male Japanese turtle mated to female white rings is given in tables 37 to 41. This includes 10 years of breeding and 11 years of the life of this particular male. Tests were made with 6 different females. A glance at the data will make it clear that the life-term of the offspring of the resulting hybrids is quite long; *longer even than that of the longer-lived parental species when its young are reared in captivity*. This we shall later see holds true also for the reciprocal hybrids.

In this fact of increased longevity in these hybrids one notes that a very important *momentum* is given to the basic and sustaining powers and processes of the organism by the "mere act of crossing" individuals of these two genera; and, having considered this point, one becomes the better prepared to interpret other unusual features of these data, particularly the data on sex. These latter features are quite probably but another aspect of the same principle which expresses itself in an increased longevity. In other words, the same thing that drives forward the life-term in all of the offspring drives forward also sex-development in all of the offspring. Germs that are not otherwise weakened may be carried by this impulse (increased vigor through a wide cross) to a higher level of sex-development than they would otherwise have attained, namely, to maleness.

Further examination of the data referred to above will show that the *fertility* of this cross is remarkably high. In 87 tests (tables 37 to 40) only 4 failed to show some development, while only 1 egg began to develop and stopped short of hatching:

⁴ The editor is making extensive studies on many subjects connected with the size, chemistry, and stored energy of the egg, and of the relation these bear to sex and fertility; on the relation of season and "crowding" of clutches to sex; and the question of the relative infertility of these hybrids. The results of these studies must appear later. The additional knowledge obtained from these sources, however, gives the editor confidence concerning some points of the present chapter which do not appear conclusive from the data available for the present volume.

3 of the 4 infertile eggs belonged, moreover, to the very first clutch of the season, while the fourth belonged to a last clutch of the season, this latter being at the same time the last clutch laid during the life of a tubercular bird. The clutch-mate to this infertile egg (table 40) produced a short-lived young, which was without trace of germ-glands. That the male parent then 10 years old also probably contributed to the weakness of these germs is attested by the result of the tests made during the following year. These latter tests are recorded in table 41, and show this 11-year-old bird to be much less fertile than when 3 to 8 years old.⁵

Three other matings of *orientalis* × *alba* have been presented earlier in another connection (tables 25, 31, 35). The females in those crosses were mated to males known to be weak in regard to fertility. In those cases many infertile eggs were present, and most of the hatched birds did not show the long term of life exhibited by the series of matings just described. Other features of the data for the *orientalis*-*alba* crosses will be considered along with similar data for the reciprocal cross.

Alba male × *orientalis* female.—The data of tables 42, 43, 44 (see also 23 and 30) demonstrate that the increased length of life observed in the hybrids above described is met with also in their reciprocals; the high degree of fertility observed there is again equally evident here. In the first case to be noted (table 42) it is only during the immaturity of the female parent, and at the extremes of the season, that there is notable infertility.⁶

The relation of the two eggs of the clutch to the production of sex, and the relation of season to sex, as it appears in the present data for the reciprocal crosses of *St. alba* and *T. orientalis*, may now be considered. In the *alba* × *orientalis* cross there occur 12 cases in which the two sexes arose from the two eggs of the same clutch. In 10 of these the first egg gave rise to a male, the females being produced from the second of the clutch in these same 8 cases. In 2 cases the reverse is true—the females here arose from the first and the males from the second of the clutch. From the *orientalis* × *alba* cross there were 12 clutches which produced both a male and a female. In 7 of these the first egg produced the male, the second egg the female, and in 5 cases this order was reversed; 3 of these reversals, however, came from a series (table 40) in which the female was probably not *pure alba*, and we have elsewhere already noted, and will later again refer to it, that when the female parent particularly is *hybrid*, the order of sexes from the two eggs of the clutch is quite irregular.⁷

The data for these crosses which bear upon the “shifting of dominance” of sex from spring to autumn, are perhaps not wholly conclusive. They do accord,

⁵ A similar result for the parents of this bird has been shown in table 19.

⁶ “See the young (No. 26, table 42) that failed to develop fully at the end of the season of 1908—October. This is a good case, as it comes from a pair that have been very fertile.” (R 16.)

⁷ The question of the relation of the order of the egg in the clutch to the production of sex in these and other crosses has been, and is being, very thoroughly studied by the editor, who will presently report the findings in full. In these studies it has become quite clear that the *yolk-size* of eggs (of pure species) is quite closely correlated with the sex of the resulting offspring; and that *yolk-size* is usually correlated with the size of the whole egg. Whitman learned that males predominate from the first egg of the clutch (see Chapters III and XIII, and he certainly had some clear evidence that the *total size* of the first egg of the clutch was usually smaller than the second (see tables 174, 176, 177). The amount of data on this latter point (weights) is so small that it seems probable that some were in manuscripts which have never been available to the editor. In our own studies the complete records on the egg-size of incubated eggs indicates that in those cases where the usual order of the sexes (in the clutch) is reversed, the order of *yolk-size* in these clutches was also reversed. In other words, maleness is associated with the smaller yolks, and usually—though not always—the small yolk is found in the first egg of the clutch.

however, with the results found generally in the other crosses, and a consideration of this matter may be undertaken in connection with these data. The effects of "season" upon sex are, after all, not easily separated from other agencies, which also influence the production of sex. Chief among these latter are the matter of the "crowding" of the clutches (overwork), the strength, vigor, health, and age of parents, and the frequent relative "weakness" of the very first egg, or pair of eggs, of the season. It will be observed in these data, and in those of other similar crosses, that "pairs of males" rarely arise in the *autumn* from *crowded* clutches, i.e., from pairs of eggs produced immediately⁸ after other eggs. Likewise "pairs of females" rarely arise from the early part of the season from *uncrowded* clutches. The health and vigor of parents can not always be known in advance, and for this reason the date of death, when known, of all parents is given in the several tabulations. The very first egg or pair of eggs in any season are found to produce a higher proportion of *females* than the next few succeeding clutches; they produce also a higher proportion of infertile eggs and of short-lived offspring than the immediately succeeding clutches, and in these several ways warrant their classification as "weak" eggs.

A condensed and classified tabulation of the "shifting of dominance" of sex of the *alba* × *orientalis* crosses is given in table 45. Here an arbitrary date—July 1 in all cases⁹—is chosen as the point of separation of early and late season. It will be noted that before July 1 there were produced 29 males to 10 females; after July 1, 31 males were produced to 33 females. Of course an arbitrary date—July 1 in this case—can not represent the proper turning-point of predominant maleness to predominant femaleness in all of the 9 series tabulated, since, for example, in some series the maximum production of males continued after July 1, and this tends in the summary to make the number of "late" season males too high. The numbers concerned are not large, but it will be observed that in the "early period," where the method of lumping the data least violates the individuality of the data, 8 of the 9 series show a strong predominance of males, and the ninth series is a small one having 1 male and 1 female. In 1908 (see table 42), 3 of the first 4 eggs of the series yielded males, while the 10 succeeding eggs gave rise to 10 females. The same pair of parents during the previous year threw 4 males and 1 female before July 1, but 3 females and 1 male after July 1.

A consideration of the sex data from these crosses is not complete without reference to the evident predominance of males over females in the offspring, notwithstanding the considerable amount of "overwork" effected in several of the series. This predominance is greater in the *alba* × *orientalis* cross than in the reciprocal cross; but the average for the two is greater than when *orientalis* is mated with *orientalis* or when the latter is mated with *turtur*, which is only specifically distinct from it. *Alba* is separated generically from *orientalis*, though they are closely related genera, having been grouped formerly within a single genus. Again the predominance of males is most pronounced (Chapter IV) when *orientalis* is crossed with *Columba*, and these two forms are separated by differences of family

⁸ About 6 days is the shortest time that an egg may be produced and laid after the second egg of the previous clutch was laid.

⁹ In the record of 1908, where every egg laid was hatched and the resulting sex ascertained in every case, the division-point is April 1, after which no males were produced, but the 10 further eggs produced females in every case.

rank. It is thus shown that if *orientalis* be mated with forms progressively more distantly related to it, the predominance of males progressively increases. It is further shown that in inbred *orientalis* there is an actual predominance of females. A summary of these data is given in table 46. The data are taken from the breeding records fully given in this and previous chapters.

RECIPROCAL CROSSES OF ST. RISORIA AND T. ORIENTALIS.

The amount of data for crosses of blond rings with Japanese turtles is not large, but it coincides with the data for the very similar cross which has just been considered, particularly in the demonstration of a high degree of fertility, of great length of life of offspring,¹⁰ and of the linkage of sex and color in inheritance. The details are presented in tables 47 and 48.

PRIMARY HYBRIDS CROSSED INTER SE AND WITH PARENT SPECIES.

Most of the possible crosses of F₁ hybrids from white rings or blond rings and Japanese turtles have been made. When back-crossed with the parent species these hybrids usually prove somewhat more fertile than when crossed *inter se*.¹¹ The results from 11 pairs are fully shown in tables 49 to 52. In every case—in back crosses and in *inter se* crosses—fertility is low and the life-term is short. It turns out, furthermore, that of 8 offspring whose gonads were examined after death, 4 were found to be inadequately or abnormally sexed. An additional 2 or 3 of such offspring (which have functioned, apparently normally, as male or female) are still alive.

The details of these matings need not be further discussed here.¹² A reference may be made, however, to table 51, in which two Japanese turtle males are shown to have been fertile to about the same very limited degree with a *risoria-orientalis* hybrid. It is of some interest to note that in these two matings the 4 eggs of this female which showed some development were all the first egg of the clutch. Again, in table 57, where a multi-hybrid is mated with a pure *St. risoria* female, there are 5 pairs of eggs which gave rise to the two sexes. In all of these 5 cases the first of the clutch produced a male and the second a female. It now seems certain that fertility and sex problems in pigeons are closely bound up with the matter of order of the individual eggs of the clutch (particularly, however, in non-hybrids), and with the order, extent, and crowding of the clutches. When fertility is very low, as in the series first mentioned above (table 51), the longevity is much decreased; but if perchance a bird can live moderately long, as did B1 of pair 6, it will often betray striking abnormalities; and these malformations are often associated with sex.

FURTHER BREEDING OF COMPLEX ORIENTALIS-ALBA-RISORIA HYBRIDS.

In tables 53 to 62 are recorded the results of a long series of matings of hybrids of the three species under examination. The data contribute in general to the thesis that "fertility is a thing of all degrees." In particular they show: (1) the

¹⁰ Several birds nearly 11 years old from this series are still alive.

¹¹ For four pairs testing absolutely infertile see list near close of Chapter II. The data left by the author do not fully decide this point, but breeding of these hybrids *inter se* by the editor has made it clear that the degree of fertility here shown for pairs 1, 3, 4, 9, and 10 is most unusual in *inter se* crosses.

¹² The limitation of color by sex shown in these matings has already been described.



- A. Parents called guinea-red and guinea-black (common pigeons, see table 70) and two of their much whitened offspring (*J 1* and *J 2*)—the last of the season of 1909. The black bird is the dam; the sire stands behind her. The two whitened young are to the left.
- B. Adult pouters, male No. 7 and female No. 8 (of table 79), and two of their strongly color-diverging offspring (*E 1* and *E 2*) from the last clutch of the season (table 80) of 1909. Young photographed Oct. 14, 1909, at about 5½ weeks after hatching. Male No. 7 stands behind the young (*E 2*), whose feathers are white in the basal portions and red-orange distally. In this young no bars are present. Female No. 8 stands in the center between the male and the rock-gray young. The color of the bars of the dam is purer white than in the sire, where white is mixed with red. Juvenal *E 1* (the bird with general rock-gray plumage) has the bars not white but red-orange.

relation of late season to infertility (tables 57, 59, 60); (2) the wide range of fertility of a male *orientalis* × *risoria* hybrid (OS 8); (3) the association of a plain gray color and "weak germs" in the further breeding of one of the offspring of this male (table 57); (4) the formation of a hybrid composed of 5 species¹³ from 2 genera (pair 25); and (5) the high frequency of abnormally sexed individuals or of hermaphrodites which result from these crosses (pairs 19, 21, 24, 27, 28). In table 62 it will be noted that when a male composed of 4 species was mated to a hybrid female the 2 resulting offspring were *both hermaphrodites*.

Further discussion of these records will not here be attempted, except for one or two points which deal with offspring and descendants of the male *orientalis* × *risoria* hybrid (OS 8) mentioned above. The data for the origin or pedigree of the several kinds of young of this bird are found in the tables (54) under pairs 14 to 18. Two of these young (OS 8 × *alba*) were mated together (brother and sister) and produced (table 55) a single bird which at a little more than 3 years of age was abnormally sexed or unsexed. There was no left gonad, and a tubercular growth was present in the region of the right gonad. In pair 20 (table 56) a son of male OS 8 and of a female *risoria-turtur-alba* seems fully fertile with a female *alba*, but the offspring are not long-lived.

In pair 21, a brother to the male of pair 20 just described was mated with a pure blond-ring female. Here, as with the brother mated to *alba*, there is at first apparently full fertility with the production of young of short life-term. But, with "crowded reproduction" in this cross, there also appears in the late autumn complete infertility, and bordering this period, both before and after, *the production of a plain gray coloration not met with in the season of full fertility and strong germs*. The two aberrantly colored forms were both short-lived and one at least was inadequately sexed, showed a symmetrical deformity of the fourth toe, and had 11 instead of 12 tail feathers. One of the sons from this mating was similarly mated to a pure *risoria*, and reproduced the longevity and fertility features of the cross just described, as may be seen in table 59.

A brother and sister (♂ OS—D 3—D × ♀ OS—D 3—E) of this last-named male proved fertile in both eggs of a single clutch (1909). The first gave rise to a female with the lighter color of the dam and lived nearly 6 months; the second young of unknown sex had the color of the sire, and lived probably more than 18 months (disappeared). A sister (OS—D 3—B) proved fertile in 1 of 6 tests (first egg of third clutch) with a male *orient.-tur.-alba* hybrid (OS—D—C). Still another brother (OS—D 3—H) proved fertile (second egg of first clutch) with a female *Streptopelia capicola*. This pentahybrid lived probably half a year. Its composition was $\frac{2}{32}$ *orient.*— $\frac{1}{32}$ *tur.*— $\frac{1}{32}$ *ris.*— $\frac{2}{32}$ *alba*— $\frac{1}{32}$ *capicola*.¹⁴

¹³ Another pentahybrid of different composition is described in the concluding paragraph of this chapter.

¹⁴ "Here the two species of turtle-doves, *T. orientalis* and *T. turtur* = ca. $\frac{1}{5}$
 The two ring-doves, *St. risoria* and *St. alba* = ca. $\frac{1}{5}$
 The Cape ring-dove = ca. $\frac{1}{5}$
 The three species of rings, total = ca. $\frac{1}{5}$

"The turtle-doves will be practically swamped and the result would be not much more than a simple cross between *St. risoria* and *St. capicola*. That is about what the immature pentahybrid appears to be. Possibly if it matures it may give some hints of other ancestry in its voice, color of eye, etc." (F 11)

TABLE 37.

♂ *T. orientalis* (35); 8/13/04; alive 1917; 12½+ yr.
 ♀ *St. alba* (67); died summer of 1906.

A 1. 5/30/06; no development.			
A 2. 6/1/06.....	1.....	8/18/10.....	4 yr. 2 mo. 17 da.
♂ <i>T. orientalis</i> (35); (same as above); 12½+ yr.			
♀ <i>St. alba</i> (87); 5/8/09; probably 3 to 5 yr.			
A 1. 3/2/07; no development.			
A 2. 3/4/07; no development.			
♂ B 1. 3/25.....	2.....	alive 2/1/17.....	10+ yr.
♀ B 2. 3/27.....	3.....	alive 2/1/17.....	10+ yr.
♂ C 1. 5/3.....	4.....	6/14/12.....	5 yr. 1 mo. 11 da.
♀ C 2. 5/5.....	5.....	alive 2/1/17.....	9½+ yr.
♀ D. 6/27.....	6.....	alive 2/1/17.....	9½+ yr.
E 1. 7/19.....	7.....	disappeared 2/1/11-11/1/12.....	4 to 5 yr.
♀ E 2. 7/21.....	8 (very dark).....	disappeared 11/28/11.....	4 yr. 4 mo. 7 da.
F 1. 8/27.....		(killed by lice).....	2 da.
F 2. 8/29.....		(killed by lice).....	2 da.
♂ G. 10/15.....	9.....	alive 2/1/17.....	9½+ yr.
♂ H 1. 2/24/08.....	10.....	dead 10/15/16.....	8 yr. 7 mo. 21 da.
H 2. 2/26/08.....		dead 3/15/08.....	18 da.
I 1. 3/22.....	11.....	4/10/08 (food ?).....	18 da.
I 2. 3/24.....	12.....	4/11/08 (food ?).....	18 da.
K 1. 4/23; developed to time of hatching (exposure ?).		L 1. 5/21; not tested.	
K 2. 4/25; developed to time of hatching (exposure ?).		L 2. 5/23; not tested.	
♀ M 1. 6/22.....	13.....	dead 12/8/15.....	7 yr. 5 mo. 16 da.
♀ M 2. 6/24.....	14.....	6/26/11.....	3 yr. 2 da.
♂ N 1. 7/30.....	15.....	alive 2/1/17.....	8½+ yr. (see pl. 10)
♂ N 2. 8/1.....	16.....	dead 4/12/16.....	7 yr. 8 mo. 11 da.
♂ O 1. 9/9.....	17.....	12/23/09.....	1 yr. 3 mo. 14 da.
♀ O 2. 9/11.....	18.....	alive 2/1/17.....	8½+ yr.
♀ P. 1/10/09.....	19.....	alive 2/1/17.....	8+ yr.
♂ Q 1. 3/5.....	20.....	alive 2/1/17.....	8+ yr.
♀ Q 2. 3/7.....	21.....	alive 2/1/17.....	8+ yr.
♀ R 1. 4/10.....	22.....	(?) alive 2/1/17.....	8+ yr.
R 2. 4/12.....	23.....	dead 5/4/09 (wry neck).....	22 da.

TABLE 38.

♂ *T. orientalis* (35); 8/13/04; alive 2/1/17; 12½+ yr.
 ♀ *St. alba* (8); 1907; 4/17/13; 6 yr.

S 1. 5/16/09.....	24.....	died early, neglected.	
S 2. 5/18.....	25.....	died early, neglected.	
T 1. 6/14.....	26.....	died before 2/1/11.	
♀ T 2. 6/16.....	27.....	alive 2/1/17.....	7½+ yr. (see pl. 11)
♂ U 1. 8/7.....	28.....	accident, 12/19/09.....	4+ mo.
♀ U 2. 8/9.....	29.....	9/17/09.....	1 mo. 8 da.
♀ V 1. 4/2/10.....	30.....	alive 2/1/17.....	7+ yr.
♀ V 2. 4/4/10.....	31.....	alive 2/1/17.....	7+ yr.
♀ W 1. 5/25.....	32.....	alive 2/1/17.....	6½+ yr.
♀ W 2. 5/27.....	33.....	alive 2/1/17.....	6½+ yr.
♂ X. 7/15.....	34.....	alive 2/1/17.....	6½+ yr.
Y 1. 8/18.....	35.....	6/9/11.....	9 mo. 21 da.
♀ Y 2. 8/20.....	36.....	alive 2/1/17.....	6½+ yr.
♂ Z 1. 10/1.....	37.....	alive 2/1/17.....	6½+ yr.
♀ Z 2. 10/3.....	38.....	2/5/11.....	4 mo. 2 da. (F 2)

Breeding continued by O. R.

♀ {A 1. 4/20/11}	} one killed hatching; other = 427 ♀	alive 2/1/17.....	6+ yr.
A 2. 4/22/11			
? ♂ {B 1. 5/22}	} one broken; other = 474? ♂	alive 2/1/17.....	6+ yr.
B 2. 5/24			
♂ F 1. 8/14.....	457.....	alive 1 2/1/17.....	5½+ yr.
♂ F 2. 8/16.....	478.....	escaped late 1914.....	3+ yr.
♂ G 1. 8/23.....	402.....	alive 2/1/17.....	5½+ yr.
G 2. 8/25; 7 day embryo; 7 da.			
? ♀ K. 10/24; hatched; died at about 2 weeks; 28 da.			(O. R.)

¹ The clutches not accounted for here were not incubated, but used in other studies.—EDITOR.

TABLE 39.

♂ *T. orientalis* (35) (continued); alive; 12½+ yr.
 ♀ *St. alba* (8) (continued).

A 1. 3/22/12; dark; deserted eggs.	D. 4/19; dark; disappeared early.
A 2. 3/24/12; dark; deserted eggs.	
B 1. 4/1; analysis.	E. 4/29; analysis.
B 2. 4/3; analysis; broken.	
C 1. 4/11; analysis.	F 1. 5/23; analysis.
C 2. 4/13; analysis.	F 2. 5/25; analysis.
♀ G 1. 6/1.....dark.....893.....	alive 2/1/17.....56+ mo.
♂ G 2. 6/3.....dark.....830.....	alive 2/1/17.....56+ mo.
♂ H 1. 6/9.....dark.....863.....	alive 2/1/17.....56+ mo.
♂ H 2. 6/11.....dark.....881.....	alive 2/1/17.....56+ mo.
♂ I 1. 6/28.....dark.....858.....	died 1/15, 14.....18 mo. 18 da.
♂ I 2. 6/30.....dark.....894.....	alive 2/1/17.....55+ mo.
J 1. 7/6; analysis.	
J 2. 7/8; analysis.	
♀ K 1. 7/26.....dark.....890.....	alive 2/1/17.....54+ mo.
K 2. 7/28; analysis.	
?♂ L. 8/3.....dark.....875.....	alive 2/1/17.....54+ mo.
♀ M 1. 8/25.....dark.....870.....	alive 2/1/17.....53+ mo.
?♂ M 2. 8/27.....dark.....824.....	alive 2/1/17.....53+ mo.
♀ N. 9/3.....dark.....810.....	alive 2/1/17.....53+ mo.
O. 9/25; analysis.	
♀ P 1. 10/7.....dark.....812.....	alive 2/1/17.....52+ mo.
P 2. 10/8; broken; laid prematurely.	(O. R.)

TABLE 40.

♀ *St. alba* till 4/17.
 ♂ *T. orientalis* (35) (cont., 4/17 till 9/20/13); alive, 12½+ yr.
 ♀ *St. alba* (649); (purity?); died 10/1/13.

♀ 649 from dealer January 31, 1913; was then a young bird 4 to 8 mo. ♂ 35 given April 17, 1913. No. 649 female mated with another *St. alba* male till April 17, 1913.

A 1. 3/21/13; not tested.	♂ D 1. 5/21/13.....dark.....781.....	alive 2/1/17.
A 2. 3/23/13; not tested.	D 2. 5/23/13; broken.	
B 1. 4/1; not tested.	♀ E 1. 5/29.....dark.....763.....	alive 2/1/17.
B 2. 4/3; not tested.	♀ E 2. 5/31.....dark.....725.....	alive 2/1/17.
C 1. 4/10; fertile; broken? 3 day embryo.	♀ F 1. 6/6.....dark.....728.....	alive 2/1/17.
C 2. 4/12; not tested.	♂ F 2. 6/8.....dark.....798.....	alive 2/1/17.
♀ G 1. 6/14.....dark.....797.....	dead 1/5/14.....	7 mo.
♂ G 2. 6/16.....dark.....717.....	dead 12/10/13.....	6 mo.
♂ and ? { H 1. 6/22.....dark.....754.....	{ one, a ♂, alive 4/1/15.....21+ mo.	
♂ and ? { H 2. 6/24.....dark.....782.....	{ other stolen 8/13/13.	
♂ I 1. 6/30.....dark.....721.....	alive 2/1/17.....	43+ mo.
♀ I 2. 7/2.....dark.....758.....	alive 2/1/17.....	43+ mo.
♂ J 1. 7/10.....dark.....796.....	alive 2/1/17.....	43+ mo.
J 2. 7/12; slightly broken; 8 day embryo.		
K. 7/21; not tested.		
♀ <i>St. ? alba</i> (772); given 1 6/16/14 (origin uncertain; probably not pure <i>alba</i>).		
♀ J 1. 8/2/14.....dark.....61.....	alive 2/1/17.....	30+ mo.
♂ J 2. 8/4/14.....dark.....81.....	alive 2/1/17.....	30+ mo.
K 1. 8/16; no development. ²		
?K 2. 8/18.....dark.....113 (crippled).....	dead 10/18/14.....	2 mo. (had no sex-glands). ³ (O. R.)

¹ From October 1, 1913, to June 16, 1914, this male (35) was kept with a *St. alba* thought to be a female, but which proved to be a male. After June 16, 1914, male No. 35 was given *St. alba* No. 772, which had already produced 18 eggs during 1914. One of 4 eggs since laid proved infertile with this male and one that hatched gave a weak, crippled (leg) bird, dead at 2 months, with no visible trace of a gonad!

² Female 772, the mother of these young, dead of tuberculosis November 23, 1914.

³ None of the tested earlier eggs of this female were wholly infertile, though 1 formed only an 8-day embryo, 1 died while hatching, and 2 were aided in breaking the shell.

TABLE 41.

♂ *T. orientalis* (35) (cont.); alive 2/1/17; 12½ + yr.♀ ½ *alba*, ½ *risoria* (nearly) (561); 4/23/14; alive¹ 2/1/17; 3+ yr.

A. 1/26/15; first egg in life, not tested.

B 1. 3/17; lost.	C 1. 3/26; infertile.	H 1. 5/10; no trace of development.
B 2. 3/19; lost.	C 2. 3/28; infertile.	H 2. 5/12; lost.
♂ D 1. 4/5; hatched; dark; A 75; alive 2/1/17.		I 1. 5/18; broken.
D 2. 4/7; disappeared.		I 2. 5/20; broken.
E 1. 4/14; broken; 8 day dead embryo.		J 1. 5/26; no trace of development.
E 2. 4/16; broken; about 3 day embryo.		♂ J 2. 5/28; hatched; dark; 954; alive 2/1/17.
♀ F 1. 4/23; hatched; dark; 177; alive 2/1/17.		♀ K 1. 6/3; dark; 919; alive 2/1/17.
F 2. 4/25; imperfect shell; broken.		K 2. 6/5; no trace of development.
♀ G 1. 5/1; hatched dark; dead (cold ?) 5/17/15.		L 1. 6/11; no trace of development.
G 2. 5/3; thin shell.		L 2. 6/13; no trace of development.

(O. R.)

¹ This dam is from an "overworked" series, and may not be of full normal strength.

TABLE 42.

St. *alba* (O); 1904 (?); 10/10/06; 2½ yr. (?).T. *orientalis* (54); 8/19/05; 11/?/09-12/?/10; 5 yr. (T).

A 1. 5/2/06; pipped, failed to hatch.

A 2. 5/6(?) /06; no development.

♂ B 1. 6/13.....dark.....1.....	8/8/06 (care ?).....1 mo. 23 da.
? ♂ B 2. 6/15.....dark.....	7/2/06 (care ?).....17 da.
? ♂ C 1. 7/21.....dark.....2.....	12/10/07.....1 yr. 4 mo. 19 da.
♂ C 2. 7/23.....dark.....3.....	between 1/1/09-2/1/11.....? 3 yr.

St. *alba* ?/?/04 (dealer); 5/17/09; probably 5 yr.T. *orientalis* (54) (cont.)

♂ A. 1/24/07.....dark.....4.....	alive 8/1/14.....7½ yr.
B. 3/1; no development.	
♀ C 1. 3/24.....white.....5.....	3/18/14.....6 yr. 11 mo. 15 da.
C 2. 3/26; no development.	
D 1. 4/27; no development.	
♂ D 2. 4/29.....dark.....6.....	3/18/12.....4 yr. 10 mo. 19 da.
♂ E 1. 6/2.....dark.....7.....	8/4/13.....6 yr. 2 mo. 2 da.
♂ E 2. 6/4.....dark.....8.....	alive 8/1/14.....7+ yr.
♀ F 1. 7/14.....white.....9.....	alive 8/1/14.....7+ yr.
♀ F 2. 7/16.....white.....10.....	4/26/13.....5 yr. 9 mo. 10 da.
♂ G 1. 8/25.....dark.....11.....	alive 8/1/14.....7+ yr.
♀ G 2. 8/27.....white.....12.....	alive 8/1/14.....7+ yr.
♂ H 1. 2/12/08.....dark.....13.....	escaped 11/26/13.....6+ yr.
♀ H 2. 2/14/08.....white.....	4/26/10.....2 yr. 2 mo. 12 da.
♂ I 1. 3/18.....dark.....15.....	10/13/12.....4 yr. 7 mo.
♂ I 2. 3/20.....dark.....16.....	alive 8/1/14.....6½ yr.
♀ J 1. 4/17.....white.....17.....	killed 10/2/13.....5½ yr.
♀ J 2. 4/19.....white.....18.....	alive 8/1/14.....6+ yr.
♀ K 1. 5/23.....white.....19.....	1/15/10.....1 yr. 7 mo. 17 da.
♀ K 2. 5/25.....white.....20.....	(lice) 6/23/08.
♀ L 1. 6/26.....white.....21.....	killed 4/9/14.....6+ yr.
♀ L 2. 6/28.....white.....22.....	killed 10/2/13.....5+ yr.
♀ M 1. 8/9.....white.....23.....	escaped 11/13/13.....5+ yr.
♀ M 2. 8/11.....white.....24.....	alive 8/1/14.....6+ yr.
♀ N 1. 9/20.....white.....25.....	alive 8/1/14.....6+ yr.
♀ N 2. 9/22.....white.....26.....	developed, not able to break through shell.
♂ O 1. 3/2/09.....dark.....27.....	died or disappeared between 2/18/13-5/1/13.....4+ yr.
♀ O 2. 3/4/09.....white.....28.....	alive 8/1/14.....5½ yr.

No other eggs during season!

(F 2)

TABLE 43.

♂ *St. alba* (410) ($\frac{3}{4}$ *alba*- $\frac{1}{4}$ *risoria*); May or June 1911; dead 11/24/13; 29 mo.♀ *T. orientalis* (500); 6/11/11; alive 2/1/17; 68+ mo.

♂ B.	6/7/12.....dark.....	805.....	alive 2/1/17.....	56+ mo. ¹
♂ C 1.	6/15.....dark.....	811.....	alive 2/1/17.....	56+ mo.
♀ C 2.	6/17.....white.....	823.....	alive 2/1/17.....	56+ mo. (a very large egg).
D 1.	6/24; no development.			
♂ D 2.	6/26.....dark.....	842.....	alive 2/1/17.....	55+ mo.
♂ F 1.	7/15.....dark.....	809.....	escaped or disappeared about 1/1/14.	
♂ F 2.	7/17.....dark.....	847.....	alive 2/1/17.....	55+ mo.
♂ H 1.	8/2.....dark.....	821.....	alive 2/1/17.....	54+ mo.
♂ H 2.	8/4.....dark.....	888.....	alive 2/1/17.....	54+ mo.
I 1.	8/13; no development.			
♂ I 2.	8/15.....dark.....	804.....	stolen 7/4/13.	
J 1.	8/23; no development.			
♀ J 2.	8/25.....white.....	833.....	alive 2/1/17.....	53+ mo.
♀ K 1.	9/15.....white.....	806.....	alive 2/1/17.....	53+ mo.
♀ K 2.	9/17.....white.....	900.....	alive 2/1/17.....	53+ mo.
♂ C 1.	5/25/13.....dark.....	716.....	alive 2/1/17.....	44+ mo.
♂ C 2.	5/27/13.....dark.....	753.....	alive 2/1/17.....	44+ mo.
♂ E 1.	6/10.....dark.....	774.....	alive 2/1/17.....	44+ mo.
E 2.	6/12; no development.			
♂ F 1.	6/19.....dark.....	723.....	alive 2/1/17.....	44+ mo.
♀ F 2.	6/21.....white.....	770.....	disappeared early.	
♂ G 1.	6/26.....dark.....	712.....	alive 2/1/17.....	43+ mo.
G 2.	6/28; broken.			
♂ H 1.	7/4.....dark.....	743.....	alive 2/1/17.....	43+ mo.
♀ H 2.	7/6.....white.....	791.....	dead 10/12/16.....	39 mo. 6 da.
♂ I 1.	7/12.....dark.....	773.....	dead 10/15/16.....	39 mo. 3 da.
♀ I 2.	7/14.....white.....	789.....	died hatching ²	0 da.
?♂ L 1.	8/9.....dark.....		died hatching.....	0 da.
L 2.	8/11; broken.			
♂ M 1.	8/19.....dark.....	746.....	alive 2/1/17.....	42+ mo.
♂ M 2.	8/21.....dark.....	778.....	alive 2/1/17.....	42+ mo.
♂ N 1.	8/30.....dark.....	709.....	alive 2/1/17.....	41+ mo.
♀ N 2.	9/1.....white.....	780.....	alive 2/1/17.....	41+ mo.

¹ The clutches (eggs) not accounted for here were used in other studies.² Note that the parents "rested" (26 days) before producing the next pair of eggs.

TABLE 44.

♂ *St. alba* (767); (nearly pure); 6/23/13; dead 9/27/15; 27 mo.♀ *T. orientalis* (500); 6/11/11; alive 2/1/17; 68+ mo.

♀ A 1.	5/1/14.....white.....	572.....	alive 4/1/15.	♂ B 1.	5/11.....dark.....	501.....	alive 4/1/15.
♀ A 2.	5/3/14.....white.....	582.....	alive 4/1/15.	♂ B 2.	5/13.....dark.....	522.....	alive 4/1/15.
♂ C 1.	5/19.....dark.....	544.....	dead 10/5/14.				
♂ C 2.	5/21.....dark.....	fully developed embryo.		D.	5/31?; broken egg.		
♂ E 1.	6/5.....dark.....	581.....	dead (starved) 7/18/14.				
?♀ E 2.	6/7.....white.....	dead (not well fed) 6/27/14.					
♀ F 1.	6/14.....white.....	48.....	alive 4/1/15.				
?♂ F 2.	6/16.....dark.....	46.....	alive 4/1/15.				
♂ G 1.	6/22.....dark.....	killed by lice 7/15/14.		♀ H 1.	7/2.....white.....	32.....	alive 4/1/15.
G 2.	6/24; laid from perch, broken.			♂ H 2.	7/4.....dark.....	43.....	alive 4/1/15.
♀ I 1.	7/11.....white.....	21.....	a nearly pure; albino; dead 8/21/14.				
♀ I 2.	7/13.....white, a weak bird, not fed, died 7/28/14.			♂ N 1.	8/31.....dark.....	118.....	alive 4/1/15.
?♂ J.	7/20.....dark.....	58.....	alive 4/1/15.	N 2.	9/2; broken.		
♀ K 1.	7/28.....white.....	94.....	alive 4/1/15.	♂ O 1.	9/21.....dark.....	166.....	alive 4/1/15.
♀ K 2.	7/30.....white.....	82.....	alive 4/1/15.	♂ O 2.	9/23.....dark.....	full term embryo, dead.	
L 1.	8/7; infertile.			?♂ P 1.	10/3.....dark.....	164.....	alive 4/1/15.
♂ L 2.	8/9.....dark.....	111.....	alive 4/1/15.	?♂ P 2.	10/5.....dark.....	136.....	alive 4/1/15.
M 1.	8/22; infertile.			?♀ Q 1.	10/28.....white.....	171.....	alive 4/1/15.
?♂ M 2.	8/24.....dark (embryo); egg broken.			?♀ Q 2.	10/30.....white.....	173.....	alive 4/1/15.
?♂ R 1.	11/29.....dark.....	killed by fall at few days old. ¹					
?♂ R 2.	12/1-?.....dark ?.....	thrown or fell from nest (to radiator) at time of hatching.					
?♂ S 1.	12/14.....dark.....	131.....	alive 4/1/15.				
♀ S 2.	12/16.....white.....	pure albino dead 1/2/15; lower jaw 1 mm. too long; two plain ovaries.					
?♂ T 1.	12/26.....dark.....	killed (by rats) 1/25/15.					
?♂ T 2.	12/28.....dark.....	killed (by rats) 1/27/15.					

¹ Note that a "rest" of 29 days preceded this pair of eggs.

(O. R.)

INHERITANCE, FERTILITY, AND SEX IN PIGEONS.

TABLE 45.—On the "shifting of dominance" of sex in crosses of alba × orientalis.

No. of female parent.	Year.	Before July 1.		After July 1.		Total.		See table:
		♂	♀	♂	♀	♂	♀	
54	1906	2	0	2	0	4	0	42
	1907	4	1	1	3	5	4	42
	1908	3	1	0	10	3	11	42
	1909	1	1	...	...	1	1	42
99	1912	3	1	...	6	5	7	23
	1913	1	0	1	0	2	0	24
500	1912	3	1	5	3	8	4	43
	1913	5	1	6	3	11	4	43
	1914	7	4	14	8	21	12	44
Total ....	....	29	10	31	33	60	43	...

TABLE 46.—On the relations between "width of cross" and the sex ratio in *T. orientalis*.

Mating.	Width of cross.	No. males.	No. females.	Ratio.
Columba × orientalis.....	Families	15	1 (or 2)	15.00 : 1 or 7.50 : 1
Alba × orientalis (spring).....	Genera	29	10	2.90 : 1
Alba × orientalis (average).....	Do.....	60	43	1.40 : 1
Orientalis × alba.....	Do.....	37	37	1.00 : 1
Average reciprocal crosses.....	Do.....	...	...	1.20 : 1
Orientalis × turtur.....	Species	7	4	1.75 : 1
Turtur × orientalis.....	Do.....	7	14	0.50 : 1
Average reciprocal crosses.....	Do.....	...	...	1.12 : 1
Unrelated orientalis.....	Same species...	33	29	1.14 : 1
Related orientalis.....	Same species (-)	21	25	0.84 : 1

TABLE 47.

♂ *St risoria* (1); (1900); 5+ yrs.♀ *T. orientalis* (13); 5/28/03; 3/4/06; 2 yrs. 9 mo. 24 da.

A 1. 4/16/04; no development.	
A 2. 4/18/04; no development.	
♂ B 1. 4/23.....	1..... alive 2/1/17..... 153+ mo. (see pl. 12).
B 2. 4/25; (?) no development.	
♀ C 1. 5/3.....	2..... 1/13/09..... 56 mo. 10 da.
♀ C 2. 5/5.....	3..... disappeared 2/1/11-11/4/13..... 82 to 114 mo.
D 1. 6/2; not hatched.	
♂ D 2. 6/4.....	4..... dead 10/12/16..... 148 mo. 16 da.
E 1. 6/25; deserted.	
E 2. 6/27; deserted.	
♂ F 1. 7/12..... dark.....	5..... 9/22/04..... 2 mo. 10 da.
♀ F 2. 7/14..... light.....	6..... 12/8/08..... 53 mo. 24 da.
G 1. 8/15 ?; not hatched.	
G 2. 8/17 ?; not hatched.	
H 1. 8/28; not hatched.	
♀ H 2. 8/30..... dark.....	7..... disappeared 4/8/06-2/1/11..... 20 to 78 mo.
I 1. 9/12; deserted.	
I 2. 9/14; deserted.	
♂ J 1. 10/23..... dark.....	8..... killed (weak) 4/28/07..... 30 mo. 5 da. +
J 2. 10/25; not hatched.	
K 1. 11/10; deserted.	
K 2. 11/12; deserted.	

TABLE 47 (continued).

♂ L 1. 3/6/05.....dark.....9.....2/5/11.....71 mo.	
♂ L 2. 3/8/05.....dark.....10.....3/23/09.....48 mo. 15 da.	
M 1. 4/8; deserted.	N 1. 4/19; deserted.
M 2. 4/10; deserted.	N 2. 4/21; deserted.
O 1. 4/28.....dark.....5/23/05.....25 da.	
♀ O 2. 4/30.....light.....11.....stolen 8/13/13.....100+ mo.	
♂ P 1. 5/28.....dark.....12.....2/5/08.....32 mo. 7 da.	
♂ P 2. 5/30.....dark.....13.....alive 2/1/17.....140+ mo.	
Q 1. 6/27; deserted.	
Q 2. 6/29; deserted.	
♀ R 1. 7/4.....light.....14.....9/28/08.....38 mo. 24 da.	
R 2. 7/6; no development.	
S 1. 8/5; broken.	T 1. 9/11; fertile, but deserted.
?S 2. 8/7.....dark ¹.....15; dead 5/14/16.	T 2. 9/13 (F 13)

¹ Apparently hermaphrodite, certainly abnormal; two flat minute gonads (4 and 5 mg.); acted as a male and fought till end for mates.—EDITOR.

TABLE 48.

♂ T. *orientalis* (14); 7/6/03; 6/3/09; 5 yr. 10 mo. 27 da.

♀ St. *risoria* (1903); 11/10/04; 1+ yr.

♂ A 1. 5/8/04.....dark.....1.....stolen 7/19/12.....98+ mo. (see pl. 13)	
♀ A 2. 5/10/04.....slightly lighter.....2.....dead 2/4/13.....106 mo. 4 da.	
♀ B 1. 5/29.....3.....alive 2/1/17.....152+ mo.	
♀ B 2. 5/31.....dark ¹.....4.....dead 1/18/12.....91 mo. 18 da.	
♂ C 1. 7/9.....dark.....5.....alive 2/1/17.....151+ mo.	
♂ C 2. 7/11.....dark.....6.....dead 10/18/08.....51 mo. 7 da.	
♀ D 1. 8/15.....dark.....7.....dead 9/9/14.....120 mo. 24 da.	
♂ D 2. 8/17.....dark.....8.....dead 5/30/15.....129 mo. 13 da.	

♂ T. *orientalis* (0); "old bird" when mated.

♀ St. *risoria* (0); age unknown.

A 1. 3/26/05.....dark golden.....9.....3/30/07.....24 mo. 4 da.	
A 2. 3/28/05.....dark golden.....10.....probably died young.	
B 1. 5/5; deserted.	C 1. 5/22; dead at 1 day, neglect.
B 2. 5/7; deserted.	C 2. 5/24; failed to hatch.
♀ D 1. 6/15.....dark.....11.....4/13/07.....21 mo. 28 da.	
♀ D 2. 6/17.....dark.....12.....1/1/09.....41 mo. 15 da.	

(F 13)

¹ Probably no attempt was made to distinguish shades of color in birds from this and succeeding clutches.—EDITOR.

TABLE 49.

Pair 1.

♂ St. *alba* (1); age unknown.

♀ *alba* × *orient.* (28); white; 3/4/09; alive 10/1/14; 5½+ yr.

A 1. 7/17/10; A-AO 1; white; dead 1/5/11.	
A 2. 7/19/10; developed a sinus terminalis, and halted.	
B 1. 8/12/10; not quite able to hatch; ² to be white.	
B 2. 8/14/10; "made no development."	(F 5)

Pair 2.

♂ St. *alba*; age unknown.

♀ *alba* × *orient.* (23); white; 8/9/08; escaped 11/13/13; 5+ yr.

A 1. 7/29/10; no development.	
A 2. 7/31/10; developed, a small blood circle.	
B 1. 8/16; developed, but failed to hatch.	
B 2. 8/18; no development.	
C 1. 9/18; A-AO 1; white; weak; died in about 24 hours.	
C 2. 9/20; developed about 7 day embryo.	(F 5)

² "This a white bird that evidently failed to hatch for lack of strength to perform the last step in its course to hatching. Weakness at end of race."

TABLE 50.

Pair 3.

♂ *St. risoria* (32) (light); age unknown.♀ *alba* × *orient.* (12) (white); 8/27/07; alive 10/1/14; 7+ yr.A 1. 7/1/10 } one hatched; white (R-AO 1); disappeared between 7/1/11 and 11/4/13. No record of other egg.
A 2. 7/3/10 }

♂ B 1. 8/10; hatched; blond-like; (R-AO 4); alive 10/1/14 = ♂ or ♀ (acts like a ♂, and infertile).

?B 2. 8/12; hatched; white; (R-AO 5); dead 1/22/11 (no gonad found).

♀ ?C 1.¹ 10/24; R-AO 6; white-shaded; bulging occiput; dead (cold) 11/8/10.

C 2. 10/26; developed, but unhatched.

(F 5)

Pair 4.

♂ *St. risoria* (92); age unknown.♀ *St. alba* × *orient.* (9); (white); 7/14/07; alive 8/1/14; 7+ yr.

?A. 7/30/10; R-AO 2; light blond; dead 8/26/10.

"I noticed Aug. 23 that this bird (R-AO 2) had an *excessively large occiput*; this part of head bulging as if swollen. Aug. 25, I found the bird with a *twisted neck*, held so that the top of the head rested on bed of nest, the beak pointing upward. The bird could not right itself and apparently had failed to get any food. I held its beak to the mouth of the male parent until it was fairly well fed. I doubt if the bird recovers its normal condition. Aug. 26 found this bird dead in the nest, the male parent standing over it, as if waiting to feed it. Death probably due to something going wrong in development; the twisted neck was a sign of this. Sex = ? ♀. (Could find no organs for certain)." (F 5)

Pair 5.

♂ *St. risoria*; age unknown.♀ *alba* × *orient.* (17); white; 4/17/08; killed 10/2/13; 5½+ yr.

A. 8/7/10; R-AO 3; blond; disappeared 7/1/11-11/4/13; "Upper mandible 1 mm. too short; later became right." (F 5)

¹ "Could not be sure of an ovary here."

TABLE 51.

Pair 6.

♂ *T. orientalis* (0); imp. from Japan between 1903 and 1905.♀ *risoria* × *orient. hyb.* (2); 5/3/04; 1/13/09.

A 1. 4/23/06; pricked shell, deserted, dead without hatching.

A 2. 4/25/06; no development.

?♂ B 1. 5/5; hatched; no plain sex-organs; bulging occiput; ¹ dead 10/27/09.

B 2. 5/7; probably no development.

C 1. 6/10; no development.

D 1. 6/23; not well tested.

C 2. 6/12; no development.

D 2. 6/25; not well tested.

E 1. 7/9 } one developed part way, failed; other no development.
E 2. 7/11 }

♂ (0) removed 7/28/06.

Pair 7.

♂ *T. orientalis* (66); 6/6/06; given 4/16/07.♀ *risoria* × *orient. hyb.* (2); same as above.²

A 1. 4/29/07; probably no development.

A 2. 5/1/07; probably no development.

B 1. 5/29; hatched; dead 7/23/08; 5½ wks.

B 2. 5/31; no development.

C 1. 6/28; no development.

D 1. 7/?; some development.

C 2. 6/30; no development.

D 2. 7/?; no development.

(F 14)

¹ "This bird has no plain sexual organs—just a trace (perhaps) of one testicle. It had behaved as a very pugnacious male trying hard to win a mate. Mated with a ring but no result, except he played his part perfectly in sitting, etc.; color intermediate, nearer *T. orient.* than *orient.* × *risoria* or *risoria* × *orient.* hybrids. It seemed a well-formed bird except that the head was noticeably enlarged at the occiput."

² Had laid 6 eggs before mating with male 66.

TABLE 52.

Pair 8.

♂ *Orientalis alba* hyb. (2); 3/25/07; alive 8/1/14; 7+ yr.♀ *St. risoria* (29); age unknown.

A 1. 4/14/08; no development.

A 2. 4/16/08; no development.

♀ B 1. 5/21; hatched; alive 10/1/14; 6½ yr.

B 2. 5/23; no development.

C 1. 6/21; no development.

C 2. 6/23; no development.

D. 7/25; probably no development.

(F 10)

Pair 9.

♂ *Risoria-orient. hyb.* (9); dark; 3/6/05; 2/5 11; 71 mo.♀ *St. risoria* (81).♂ A. 5/27/10.....SO-R 1.....rich ruddy *risoria*.....dead 5/26/13.....36 mo.

B 1. 7/4.....SO-R 2.....brownish gray; down darker; disappeared between 2/5 11 11/4/13.....8 to 35 mo.

♂ B 2. 7/6.....SO-R 3.....brownish gray; down lighter; dead 3/4/12.....20 mo.

(F 5)

Pair 10.

♂ *Risoria-orient. hyb.* (9); same as above; 71 mo.♀ *Risoria-alba* × *douraca* (4); white; 6/29/08; 11/10/10; 16½ mo.A 1. 8/31/10.....SO-RD 1.....interm. *risoria-orient.*; no later record.....?♀ A 2. 9/2/10.....SO-RD 2.....lighter, like *risoria*; dead 12/30/10.....3 mo.

B 1. 10/14.....SO-RD 3.....like sire; disappeared 2/5/11-11/4/13.....16 to 36 mo.

B 2. 10/16.....SO-RD 4.....complexion dark; thrown from nest killed at 1 da. (F 3)

Pair 11.

♂ *Orient.* × *risoria* (5); 7/9/04; alive 6/1/14; 10+ yr.♀ *Risoria* × *orientalis* (2); 5/3/04; 1/13/09; 56 mo.

♀ F 1 or 2. 8/2/05; pricked shell, failed; 10 to 12 other tests showed no development.

A 2. 4/10/06; began development.

(F 18)

TABLE 53.—Other fertility tests of *orientalis* hybrids crossed with *risoria* and its hybrids.

Pair 12.

♂ (H 1) *Domestica* × *orientalis* hyb.; (1898); 11/15/07; 9 yr.♀ (M 1) *Risoria-alba* × *homer* hyb.; (4/27/98).

These birds mate, build nests, copulate, etc., month after month, (1899) but no eggs. Same ♂ with ♀ common pigeon, 2 to 4 tests 1900. No development. (Probably M 1 was not a female.—Editor). (A 13)

Pair 13.

♂ *Orientalis-risoria* (?)♀ *Risoria-douraca* (?)

Such a mating (can not find original data—Editor) produced at least 1 offspring. ♀ OS-RD-2 hatched before Nov. 1910 (probably 1908-9); escaped 8/4/13; 3+ yrs. (O. R.)

TABLE 54.

Pair 14.

♂ *Orientalis* × *risoria* hyb. (OS 8); 8/17/04; alive 4/1/15; 11+ yr.♀ *Risoria-alba* × *turtur* × *alba* (D 9); 7/25/04; alive 1907; 3+ yr.A. 8/31/05; hatched; color nearly ♀ *ris-orient. hyb.*¹; dead 10/2/05; 1+ mo.

♂ B 1. 4/4/06; (OS 8-D 1).....color light.....dead 11/6/07.....19 mo.

B 2. 4/6/06; developed a little.

♀ C 1. 5/5.....OS 8-D 2.....light w. dull turtle spots.....dead 10/7/08.....29 mo.

C 2. 5/7; did not hatch.

D. 6/15; did not hatch.

♂ E. 7/9.....OS 8-D 3.....color closely that of sire.....dead 2/1/09.....31 mo.

♀ D 9 probably sick 1907; winter 1907-08 plainly tubercular.

In 1907 mated with a female *St. risoria*; no result, or record not available.

Pair 15.

In 1908 a female white ring (*St. alba* 1) was given.

A 1. 2/28/08; no development.

♂ A 2. 3/1/08.....OS-A.....very light blond.....dead 2/1/11-7/1/11.....? 36 mo.

♂ B 1. 4/2.....OS 8-B r.....dark.....dead 12/27/09.....21 mo.

♀ B 2. 4/4.....OS 8-B 1.....light as OS-A; (thrown from nest), killed 4/20/08.....8 da.

¹ The results of this cross therefore = ½ orient. + ½ tur. + ¼ ris. + ¼ alba.

TABLE 54 (continued).

C 1. 4/28; probably no development (incubation not perfect).	
C 2. 4/30; probably no development (incubation not perfect).	
♀ D 1. 5/20.....	OS 8-D r.....rather ring-like (trace of tur.).....dead 12/10/09.....19 mo.
♂ D 2. 5/22.....	OS 8-D l.....pale blond.....dead 12/3/08.....6 mo.
♂ E 1. 8/22.....	OS 8-E.....darker shade, fertile.....dead 11/19/10.....29 mo.
♀ E 2. 6/24.....	OS 8-E.....lighter shade like risoria.....dead 11/25/09.....17 mo.
F 1. 7/22; no development.	
F 2. 7/24; no development.	
G 1. 8/29.....	OS 8-G r.....dark, but lighter than sire.....dead 12/24/09.....16 mo.
♀ G 2. 8/31.....	OS 8-G l.....lighter, more like risoria.....alive 2/1/11.....30+ mo.
♂ H 1. 9/18.....	OS 8-H r.....light, as lighter risoria.....dead 3/27/09.....6 mo.
♂ H 2. 9/20.....	OS 8-H l.....quite dark ².....dead 12/26/09.....15 mo.
♂ I. 11/15.....	OS 8-I.....an even dark (intermed.).....dead 12/10/08.....1 mo.
J 1. 12/5; pricked shell and died.	
J 2. 12/7; no development.	
K 1. 2/26/09; (chilled); pricked shell (late), was helped out and died 1st day; lighter than K 2.	
K 2. 2/28/09.....OS 8-K.....dark.....dead 3/4/09.	
L 1. 3/4.....	OS 8-L.....dark
L 2. 3/6.....	OS 8-L.....dark
} one probably dead 1/23/10; other no record.	

♀ alba × orientalis (17) given 1909. Only one egg; no development=pair 16.

Pair 17.

Later a grand-daughter given as mate. This new ♀ (OS-D 3-F) was from OS 8-D 3 above and a ♀ blond ring, and hatched 1908.

♂ A 1. 4/20/10; same shade of brown as dark hyb. of orient. × risoria dead 5/4/10; 2 weeks.

A 2. 4/22/10; no development.

Pair 18.

♀ $\frac{1}{2}$ ris.- $\frac{1}{2}$ alba × $\frac{1}{2}$ douraca hyb. (RD 5) given near end of Aug. 1910.

♂ A 1. 9/2/10; color, like risoria; dead 10/10/10.

♀ A 2. 9/4/10; color, darker, more like tur.-risoria hyb.; dead 12/30/10.³

² "This pair of young repeat the two colors of the previous pair, but the first egg here produces light instead of dark color, and the second egg here produces dark instead of light." (F 4)

³ The data for the bigeneric hybrid OS 8 show it to have been fertile with:

(a) the trispecific hybrid D 9 (=ris.-tur.-alba).

(b) the pure *St. alba* (1).

(c) the related (grand-daughter) tetrahybrid OS 8-D 3-F (= $\frac{1}{8}$ orient.- $\frac{1}{8}$ tur.- $\frac{1}{4}$ ris.- $\frac{1}{2}$ alba).

(d) the trispecific hybrid RD 5 (= $\frac{1}{2}$ ris.- $\frac{1}{2}$ alba × $\frac{1}{2}$ douraca).

Lighter and darker shades appear, but in most cases the special colors of the several species entering into the cross is noted.

TABLE 55.

Pair 19.

Two of the above offspring (♂ OS-A and ♀ OS 8-G=brother and sister from OS 8 × a pure alba) were mated 1910, producing the following:

?A. 5/15/10.....2 OS-A 1.....roseate blond.....killed 9/10/13.....40+ mo.

This bird had a large tubercular growth in the region of the right¹ gonad, but no gonad discoverable.

The only offspring of this brother-sister mating, in which the parents were trispecific hybrids, was therefore an imperfectly sexed individual.

¹ The normal female pigeon has only one gonad—the left; the normal male has two.—EDITOR.

TABLE 56.

Pair 20.

♂ OS 8-D 1 (= $\frac{1}{2}$ orient.- $\frac{1}{2}$ tur.- $\frac{3}{8}$ ris.- $\frac{1}{8}$ alba); pale blond; 4/4/06; dead 11/6/07; 19 mo.

♀ *St. alba*=from ♂ (1) × ♀ (1)

Composition of young = $\frac{1}{8}$ orient.- $\frac{1}{8}$ tur.- $\frac{1}{4}$ ris.- $\frac{3}{8}$ alba.

A 1. 5/6/07; OS-D-A 1; color, size, shape as in sire; dead 11/28/07; 7 mo.

A 2. 5/8/07; complexion of A 1; (poor care?); dead 5/25/07; 2 da.

B 1. 6/15; egg lost.

B 2. 6/17; egg lost.

♂ C 1. 7/7; OS-D-C r.....color like sire; (fertile); dead between 2/1/11 and 11/4/13; 4 to 5 years.

♀ C 2. 7/9; OS-D-C l.....trace lighter than C 1; dead 11/14/07; 4 mo.

(F 1)

TABLE 57.

Pair 21.

♂ OS 8-D 3 (= $\frac{1}{2}$ orient., $-\frac{1}{2}$ tur. $-\frac{1}{2}$ ris. $-\frac{1}{2}$ alba); dark; 7/9/06; dead 2/1/09; 31 mo.

♀ St. risoria (stray bird, captured, May 1907); isabelline.

The young of this pair have the composition: $\frac{1}{2}$ orient. $\frac{1}{4}$ tur. $\frac{1}{4}$ ris. $\frac{1}{4}$ alba.

A 1. 5/28/07	OS-D 3-A-r	ring-like nearly	dead before 2/1/11	? mo.
♂ A 2. 5/30/07	OS-D 3-A-l	darker than A 1, nearer sire	dead 11/7/09	29 mo.
♂ B 1. 7/18	OS-D 3-B-r	ruddy-color of risoria	dead 11/5/07	3½ mo.
? ♀ B 2. 7/20	OS-D 3-B-l	strong ruddy of risoria	dead 10/23/13 ¹	75 mo.
♂ C 1. 8/27	OS-D 3-C-r	reddish ring-dove	dead 11/30/07	3 mo.
♀ C 2. 8/29	OS-D 3-C-l	reddish ring-dove	dead 11/10/07	2½ mo.
♂ D 1. 2/23/08	OS-D 3-D-r	dark, toward sire; (fertile)	dead 12/9/09	21½ mo.
♀ D 2. 2/25/08	OS-D 3-D-l	a ruddy ring-dove	dead 12/10/09	21½ mo.
♂ E 1. 4/10	OS-D 3-E-r	nearly like sire	dead 6/15/08	2 mo.
♀ E 2. 4/12	OS-D 3-E-l	ring-like; (fertile)	dead 11/7/09	19 mo.
♂ F 1. 5/22	OS-D 3-F-r	inclines to dark	dead 10/16/09	17 mo.
♀ F 2. 5/24	OS-D 3-F-l	lighter than F 1; (fertile)	dead 5, 15/10	24 mo.
G 1. 7/2; did not develop.				
? ♀ G 2. 7/4	OS-D 3-G-l	plain gray like douraca ² (probably died young).		
H 1. 8/3	OS-D 3-H-r	dark-ring-like	one dead 1/3/11	29 mo.
♂ H 2. 8/5	OS-D 3-H-l	lighter; (fertile)	other 4/29/11	33 mo.
I 1. 9/20; no development.			J 1. 10/24; no development.	
I 2. 9/22; no development.			J 2. 10/26; no development.	
K 1. 12/30; plain gray, like douraca, dead between 2/27/09 and 2/1/11.				2 to 25 mo.
♀ K 2. 1/1/09		color nearly like sire	dead 2/10/09	1½ mo.
♂ parent dead 2/1/09, "a fine looking bird."				(F 1)

¹ Gonad certainly abnormal; no distinct ovary, but a few scattered ova less than 1 mm. in region where ovary should have been.—EDITOR.

² Besides the unusual color and somewhat uncertain sex, this bird shows other abnormalities. "It had only 11 rectrices, and the fourth toe on each foot is bent inward (symmetrical). Bird is a little weaker in size than earlier birds of this season."

TABLE 58.

Pair 22.

♂ *Orientalis-risoria* × alba (OS 8-E); dark; 6/22/08; 11/19/10; 29 mo.♀ *Orientalis-risoria* × ris-turtur × alba (OS-D 3-F); light; 5/24/08; 5/15/10; 24 mo.

♂ A 1. 7/2/09	OS-E 1	nearly dark as sire ¹	dead 11/25/09	5 mo.
♂ A 2. 7/4/09	OS-E 2	nearly dark as sire	dead 10/21/09	4 mo.

¹ Offspring = $\frac{1}{4}$ *orientalis* - $\frac{1}{4}$ *turtur* - $\frac{1}{4}$ *risoria* - $\frac{1}{4}$ *alba*.

TABLE 59.

Pair 23.

♂ OS-D 3-A ($\frac{1}{2}$ orient. $-\frac{1}{2}$ tur. $-\frac{1}{2}$ ris. $-\frac{1}{2}$ alba); darker than ring; 5/30/07.

♀ St. risoria; dead 11/7/09; 29 mo.

A 1. 5/7/08	OS-D 3-A-A r	color dark	dead before 2/1/11	?
♀ A 2. 5/9/08	OS-D 3-A-A l	more ring-like (i.e., lighter)	dead 5/13/09	12 mo.
B 1. 6/17; complexion dark; killed very young.				
♀ B 2. 6/19	OS-D 3-A-B	lighter than B 1.	dead (lice ?) 7/4/08	
♂ C 1. 7/10	OS-D 3-A-C r	like sire	dead 8/26/09	13½ mo.
♂ C 2. 7/12		similar to C 1.	dead 9/1/09	13½ mo.
♂ D 1. 8/22	OS-D 3-A-D r	color of sire	dead 9/11/09	13½ mo.
♂ D 2. 8/24	OS-D 3-A-D l	complexion ring-like	dead 10/8/08	1½ mo.
E 1. 10/18	OS-D 3-A-E r	color nearly of sire; frozen (?) 1/1/12		39 mo.
E 2. 10/20	OS-D 3-A-E l	a little darker than dam; dead 12/20/09		14 mo.
F 1. 12/26; no development.				
F 2. 12/28; no development.				
♂ G 1. 2/25/09	OS-D 3-A-G r	color of sire	dead 1/24/10	11 mo.
♂ G 2. 2/27/09	OS-D 3-A-G l		dead 10/23/09	8 mo.
♀ H 1. 5/15	OS-D 3-A-H r	nearly like sire	dead 9/7/09	4 mo.
♂ H 2. 5/17	OS-D 3-A-H l	lighter than sire	dead 9/11/09	4 mo.
♂ I 1. 8/16	OS-D 3-I r	dark as sire, nearly	dead 1/31/10	5½ mo.
♀ I 2. 8/18	OS-D 3-I l	color of dam	dead 2/1/10	6½ mo.

TABLE 60.

Pair 24.

♂ *Turtur-orient. hyb.* (5); 6/6/04; alive 8/1/14; 10+ yr.♀ *Humilis* × *hum.-risoria hyb.* (HHR 2); 8/17/05; 8/20/08; 36 mo.

A 1. 4/15/07; no development.

A 2. 4/17/07; no development.

♂ B 1. 5/7.....TO-HR 1.....like sire or turtur (fertile)...dead 1/15/09 (care).....20+ mo.

♂ B 2. 5/9.....TO-HR 2.....like sire or turtur (fertile)...dead 10/9/09.....29 mo.

C 1. 6/15; developed (deserted on train).

C 2. 6/17; developed (deserted on train).

D 1. 7/4.....TO-HR 3.....color ?.....dead at 12 days.

D 2. 7/6.....TO-HR 4.....color ?.....dead at 16 days.

E 1. 8/9 } one began development (unsteady incubation ?).

♀ E 2. 8/11 } one.....TO-HR 5.....color ?.....dead 12/5/07.....4 mo.

F 1. 3/21/08 } one.....TO-HR 6.....skin and down dark.....dead before 2/5/11.....?

F 2. 3/23/08 } one.....TO-HR 7.....skin and down trace less *dark*; dead before 2/5/11.....?

G 1. 4/2.....TO-HR 8.....complexion about that of F 1 and F 2; dead before 2/5/11.....?

G 2. 4/4; no development.

H 1. 4/20; no development (care ?).

♀ H 2. 4/22.....TO-HR 9.....like sire; toward turtur.....dead 8/13/08.....4 mo.

I 1. 5/10; no development.

♀ I 2. 5/12.....TO-HR 10.....dark (more like dam than previous young); dead (food ?)....4 mo.

♀ or ♂ J 1. 7/7.....TO-HR 11.....dark "as usual" (? *hermaph.*); killed 5/1/12.....46 mo.¹

J 2. 7/9.....developed 12 day embryo (2 day of hatching) upper jaw curved to left. (F 16)

Pair 25.

♂ *Turtur-orient.* × *hum.* × *hum.-risoria hyb.* (TO-HR 1); 5/8/07; 1/15/09 (care); 20 mo.♀ *St. alba*; age and parents unknown.♂ A 1. 6/19/08; color and appearance ² of *humilis*, trace lighter, dead at 25 da.

A 2. 6/21/08; no development.

B 1. 7/4; no development.

B 2. 7/6; no development.

C 1. 8/4; no development.

C 2. 8/6; developed, pricked shell, failed; complexion dark like A 1. (F 19)

¹ This bird had an ovary on the left side, but in addition there seemed to be a right gonad involved in a very large tumor. The bird was killed *fighting*; had a body unnaturally rounded for a dove. Until opened for autopsy thought to be a male; it had certainly behaved so as to give this impression.—EDITOR.

² Young = $\frac{1}{2}$ *turtur*, $\frac{1}{4}$ *orient.*, $\frac{1}{8}$ *hum.*, $\frac{1}{8}$ *risoria*, $\frac{1}{2}$ *alba*.

TABLE 61.

Pair 26.

♂ *Turtur-orient.* × *hum.* × *hum.-risoria hyb.* (TO-HR 2); dark with red (*turtur*); 5/9/07; 10/9/09; 29 mo.♀ *St. risoria*; age and ancestry not given; isabelline.

♂ A 1. 7/5/08.....TO-HR-R 1.....dark, more like sire.....dead 8/22/10.....25½ mo.

♂ A 2. 7/7/08.....TO-HR-R 2.....dark, more like sire.....dead 7/24/09.....13 mo.

♀ B 1. 8/15.....TO-HR-R 3.....interm. to parents.....dead 2/24/10.....18 mo.

♂ B 2. 8/17.....TO-HR-R 4.....dark reddish brown; turtur neck-mark; dead 2/8/09.....6 mo.

Pair 27.

♀ *St. risoria* (2d female here) given 4/14/09.

♂ A 1. 4/21/09.....TO-HR-R 5.....complexion dark.....dead (cold ?) 5/29/09.....38 da.

♂ A 2. 4/23/09.....TO-HR-R 6.....color dark, as most young.....dead 5/23/09.....30 da.

B 1. 5/19.....TO-HR-R 7.....dark, toward *humilis* (much as former birds); 8/19/10.....15 mo.

B 2. 5/21; no development.

? C 1. 6/16.....TO-HR-R 8.....dark as most others; sex abnormal;¹ dead 9/15/09.....3½ mo.

C 2. 6/18; hatched (color of C 1) with deformed legs; killed 7/8; 1 mo.

♂ D 1. 8/1.....TO-HR-R 9.....dark like most former birds; dead of tuberculosis at 14 mo.

♂ D 2. 8/3.....TO-HR-R 10.....dark like others.....dead 11/4/09.....3 mo.

(F 6)

¹ "Sex?; I could find no male or female organs."

TABLE 62.

Pair 28.

♂ $\frac{1}{2}$ *orientalis* - $\frac{1}{2}$ *risoria* - $\frac{1}{4}$ *turtur* - $\frac{1}{4}$ *alba* hyb. (H); 8/2/08; 1/3/11.♀ *alba* × *orientalis* hyb. (22); 6/22/08; 10/2/13; (killed).♀ ♂ A 1. 7/29/10; hatched,¹ killed 4/7/14; (*hermaphrodite*) predominantly ♀.²♀ ♂ A 2. 7/31/10; hatched, killed 4/7/14; (*hermaphrodite*) predominantly ♀.²

(F 5)

¹ "Notice that in these final hybrids (A 1 and A 2) we have but four species represented, three of which are pretty evenly balanced, each representing about 1/3. The fourth (*Turtur turtur*), the European turtle-dove, is only 1/32 of the whole. The Oriental turtle and the white ring are each 10/32, while the blond ring is 11/32. The color of these hybrids is about what might be expected if the colors of their ancestors were evenly blended. If we regard the white ring and the blond as two very closely allied species—as practically one species—then our hybrids represent about 2/3 ring and 1/3 Oriental turtle. This is, approximately, what the hybrids actually appear to be." (F 5)

² "The upper mandible in both A 1 and A 2 is bent a little to the right, forming a sort of cross-bill. I noticed this on the 2d day, and it has not thus far (8/18) changed much. On 9/16/10 the bills are noted as more strongly crossed than at first; the lower bill now turning to the right." In making the autopsies of these birds, the editor failed to note anything concerning their bills. It seems likely that these were nearly normal. These birds for a long time before being killed were thought to be males, as they certainly contested for mates—fighting so that they continually had all the feathers stripped from their necks, and mostly from their heads. Strangely enough an examination of the record of A 1 indicates that this bird laid several eggs during 1911, while mated with a *St. risoria* male, and that one of the eggs is noted as showing "some development." During the last two years of its life, however, there is no doubt whatever that it laid no eggs and acted as a male. The birds were healthy when killed. Indeed, they were killed because it was thought they would yield abundant material for testis extract. The autopsies of these birds so far as they relate to sex are given herewith in full:

No. OS-DAO 1 (= A 1) is a probable *hermaphrodite*. Left gland is ordinary size of ovary for this bird (= about 0.190 to 0.200 gr.). This contains a medial and posterior part plainly ovarian in nature—i.e., shows numerous small ova and some large clear globules posteriorly. The anterior part is testis-like. But there is also a *right gland*, about one sixth of the size of the left, and of doubtful nature, i.e., testis or ovary.

No. OSDAO 2 (= A 2) is practically same as above. Left gland ordinary size and shape of ovary and showing innumerable small ova all less than 0.5 mm., rather homogeneous in contrast to above. A very small, elongate (8 to 10 mm.) right gonad found. Near center of this are ova of 0.5 to 1.5 mm.; quite resembling structure of left gonad—i.e., seems ovarian.

Both of above birds had behaved like males; i.e., had been very aggressive, and had all their neck feathers pulled out in the contest for mates.

CHAPTER VIII.

GUINEA-PIGEONS CROSSED WITH COMMON PIGEONS.

The results of crossing the male guinea-pigeon (*Columba guinea*)¹ with female homers and domestic doves (and with their hybrids) bring into relief several of the most interesting phenomena of hybridization: (1) the shortened life-term of the hybrid (in *some* crosses); (2) the lesser compatibility of sperm with the ova of hybrids than with ova from a pure strain; (3) the difference in developmental strength of the germs of individuals of the same strain; (4) the lesser strength of germs produced "out of season" or late in the season; (5) the quantitative nature and basis of fertility; and (6) the power of the sperm of one species to affect the rate of development² of the ova of another species. All of the author's data and observations on these points are given in connection with the several tables. The following textual statements and the summaries are made by the editor.

The detailed histories of two of these matings, each extending over a period of 5 years, are given in full in tables 63, 64, and 65. The two male guinea-pigeons used in the matings are designated *G 1* and *G 2*. It will be observed in the tables just cited that *G 1* was mated to 4 different females, and *G 2* to 6 different females; also that they were mated to birds of similar constitution, and that finally both males were tested with the same individual female.

We shall analyze these data rather more fully than is done in most cases elsewhere in this volume, partly because this treatment may assist the reader not only at this point but at others where a minimum of analysis is given, partly because the data here are very complete and unequivocal, and again because some comparisons of the results of one of the series of crosses with the other series might otherwise be overlooked.

The birds concerned in these crosses are of the same genus (see the preceding note), but are very different and probably rather distantly related species. In accord with this the percentage of "infertile" eggs—*i. e.*, eggs capable of little or no development—is high. But the general level of infertility is probably not equally high in the two series. For male *G 1* this percentage is 56, or 24 of 43 tests.³ For *G 2* this percentage of infertility is 43, or 15 of 35 tests.⁴ In partial explanation of this difference, however, the fact that male *G 1* and consorts produced a total of 56 eggs to only 39 in the other series (overwork) is a matter to be considered. The unequal number of eggs produced during the "out season" would also probably serve to explain still another part of this apparent difference. Nevertheless, male *G 1* shows, in 3 of the 4 matings which are wholly comparable with the 5 matings of male *G 2*, a smaller percentage of eggs capable of beginning development (*G 2* ×

¹ "Salvadori (p. 241) states that he feels 'sure that the numerous species of *Columba* ought to be arranged in several subgenera.'" (See pl. 80, Vol. I.)

² "This time (for eggs of homer fertilized by *C. guinea*) is 1½ days shorter than in homers and domestic pigeons, and is again a proof that the male influences the rate or speed of development" (P3). The subject is treated in Chap. XVI.—Editor.

³ 11 eggs with "no record," but probably nearly all of no development, are not included; this makes the figure 55 per cent too low.

⁴ Only 2 cases of "no record, probably no development," and eliminating the mating of sire to daughter, not represented in matings of *G 1*.

owl-rock is the exception). Furthermore, those that did begin to develop stopped sooner, producing birds of a shorter term of life ($G 1 \times$ homer of 1903 is a possible though not a probable exception). Of the 19 eggs of Series I which showed any capacity for development, only one lived more than 19 days, as compared with 8 individuals from the 20 eggs of the other series which lived more than 7 months. Thus it is here clear that the series of "least fertility" is also the series of "shortest-lived" offspring.

In Series I, moreover, it is evident that when the female is more nearly pure (*C. tabellaria*), not obviously hybrid (owl-rock), that both eggs of the clutch are rarely fertilizable; in none of the 12 clutches did both eggs show development.⁵ In Series II, however, the 11 clutches (one clutch had but 1 egg) which showed development showed it in both eggs of the clutch in 8 cases; 2 of the 3 exceptions are *first* and *last* clutches of the season. The two series illustrate the fact that *it is when the developmental power of the germs is most strongly reduced that the breeding evidence becomes clearest for the developmental (as apart from sexual) non-equivalence of the two eggs of the pigeon's clutch.*

When owl-rock hybrids are mated (4 matings) with the males of either series, the percentage of infertility is higher than when *pure*⁶ *tabellaria* or *domestica* is used, and at the same time the young that develop from the hybrid unions have a shorter term of life than have the young from females of pure strain.

♂G 1. \times owl-rock; 6 young lived—3, 7 days; 1, 5 days; 1, 8 days; 1, 10 days; average, 7 days.

♂G 2. \times owl-rock; 4 young lived—3, 7 days; 1, 10 days; average, 8 days.

♂G 1. \times homer; 8 young lived—2, 1 day; 2, 9 to 10 days; 3, 14 to 19 days; 1, 15 months; average, 64 days.

♂G 2. \times homer; 6 young lived—1, 10 months; 2, 12+ months; 3, 20 months; average, 470+ days.

♂G 2. \times domestica; 9 young lived—6, 5 to 10 days; 1, 14 days; 1, 11 months; 1, 30+ months; average, 142+ days.

The data thus far considered lead, then, to the conclusions which are generally supported by the data from other groups: (1) that fertility is a matter of all degrees; (2) that proper crosses enable one to see and study the intergradations and flowing levels of this important function; (3) that hybridization, even within the limits of the breeds of common pigeons, makes their ova less compatible with the sperm of one wild species; and (4) at the same time sets a sentence of a shorter term of life upon the developments which proceed from their more compatible gametes.

The non-equivalence of the two eggs of the clutch, particularly well seen in cases where there can be but little development (as in $G 1 \times E 2$), has also been indicated. It remains to point out that these data further show that germs produced at the extremes of the seasons are weak in developmental power; fewer of such eggs develop, and shorter lived offspring arise from them. This result can here be best presented⁷ in a table showing the outcome for the eggs of each month of the year. Eliminating the record in Series II for the whole years in which no fertile eggs were produced, the data are as shown in table 66.

It will be seen that the "highest fertility" and "longest life" are both resident in the eggs produced in May. The second for fertility is April; the second for longevity is March. The lowest fertility is found in December, January, February, and August.

⁵ The egg of greater developmental strength and of male-producing tendency seems in domestic pigeons, even of so-called "pure strains," to bear no definite relation to the order of the eggs in the clutch. This is as in hybrids generally.

⁶ By "pure" of course only "relatively pure" is meant when speaking of common pigeons.

⁷ All such methods of grouping and treating data not entirely homogeneous are of course open to objection but an estimate of the situation under analysis can be thus presented.

That individual homers differ (or that the male guinea-pigeons differ) in respect to fertility is amply shown by the different results obtained from the homers *E 2* and "2-barred of 1903." Of the eggs of the former only 8 of 22 tested showed any development; the longest life of offspring here was 19 days (with *G 1*). In contrast, 7 of 10 eggs of the other homer were hatched (mated to *G 1* and *G 2*), and all the offspring lived from 10 to 20+ months.

TABLE 66.—Fertility and length of life from eggs (guinea-pigeon series) laid during various months of the year.

Month.	No. laid.	No. tested.	No. fertile.	No. infertile.	P. ct. of fertility.	Length of life.
March	7	5	3	2	60	5 days, 19 days, 15 months.
April	15	15	10	5	67	1 day embryo, 3 hours, 5 days, 7 days, 9 days, 10 days, 10 days, 12 to 13 days, 14 days.
May	10	7	6	1	86	1 day, 10 days, 11 months, 12+ months, 20+ months, 30+ months.
June	8	7	3	4	43	9 days, 5 to 7 days, 5 to 7 days.
July	16	16	9	7	56	15 day embryo+, 7 day, 7 day, 7 day, 14 day embryo; 10 months, 12 months, 7 days, ? 7 days.
August	5	3	1	2	33	7 days.
September . .	3	2	1	1	50	7 days.
October	8	8	5	3	62	5 days, 8 days, 18 days, 19½ months, 20¼ months.
November . .	2	2	1	1	50	14 days.
December . .	1	1	0	1	0	
January	3	1	0	1	0	
February . . .	4	2	0	2	0	

One further point should be considered, namely, the reproductive disturbances appearing in the hybrids of these two series. No narrowly limited number of hybrids, from a primary cross, will present many cases of reproductive abnormalities or disturbances; each of the two present series contains one. In the mating of *G 1* × homer *E 2*, where we noted in the preceding paragraph very restricted fertility and short life of offspring, one of the young (*J 1*) lived 1 day longer than any of its fraternity; nevertheless at 19 days old it had no evident sex-glands. Professor Whitman's records show numerous isolated instances of this sort of thing, though he has nowhere commented upon the matter. The editor has, however, made a great many autopsies of the birds of the author's collection and of many others bred by himself, and is convinced that such histories as that of *J 1* now under consideration is typical of a small but notable fraction of the hybrid offspring of doves and pigeons. *Some hybrids—a much higher proportion than pure breds—develop no sex-glands, or they develop diminutive or otherwise abnormal ones.*

The second instance of reproductive abnormality in this group is of another kind. This is the instance tabulated in table 65, in which a hybrid daughter (*guinea* × *domestica*, *C*) mated perfectly with her sire, but in 4 months of mating produced no eggs. Nor are there any later records of eggs from this bird. A record of an autopsy of this bird can not be found, but she is unqualifiedly listed as a female, and certainly behaved as one; if in reality she had male sex-glands, then her reproductive abnormality would lie in this feminine behavior.

The sex data for the offspring of *G 1* and his consorts (the less-fertile series) are: 3 males and 1 unsexed (?) bird of 19 days. The more fertile series (II) gave 3 males and 5 females. Four of these 5 females arose from the most fertile—and otherwise the most normal—mating of either series.

One would wish to know what the reciprocal of this cross (σ^7 common \times φ guinea) would show. Only a single mating of this sort is recorded, and from this but a single clutch of eggs was obtained. The data are:

σ^7 *C. domestica*; black with chequers. A 1. 5/27/10; dead 3 days after hatching.

φ *C. guinea* (19); dead 6/22/10 A 2. 5/29/10; no development.

(P 5)

Matings and Back-Crosses of Guinea Hybrids.—In the mating and back-crossing of guinea-homer hybrids many of the fertility and longevity features of the primary cross reappear—low fertility, seasonal and individual differences of fertility, and a shortened life-term of the offspring. Nevertheless, this term of life is here an advance over the longevity of the primary cross, where, however, the life-term was *extremely* short.

Three matings involving 4 individuals of the second generation guinea hybrids ($\frac{1}{4}$ guinea, $\frac{3}{4}$ homer) were made. The sires of the first two matings were brothers. Two were mated back to homers. The results, placed in table 69, show low fertility for the pair of inbred secondary hybrids, but fair fertility and perhaps longer life-terms than were obtained from the primary hybrids. Two birds from secondary hybrids lived for 27 months, one lived 32 months. This seems to be near the extreme limit of life of these hybrids from species whose individuals usually live probably 5 to 15 years.

One additional point is indicated by the result of the matings of the primary hybrids, namely, that the males seem more fertile in the back-cross than are the females. Three of each were tested with homers. From all the matings of such males eggs (9) were hatched. Not one egg from the pairing of female primary hybrids with male homers was hatched; only 3 of their germs showed any fertility, and there was a minimum of growth in these—a “circle of blood,” a “little development,” and again a “little development.”

TABLE 63.

Series I.

σ^7 *C. guinea* (1); escaped April 1904.

φ *C. tabellaria* (E 2); 8/24/99.

A 1. 4/26/00; no development.

A 2. 4/28/00; dead 3 hours after hatching (partly helped from shell).

B 1. 5/24; dead 24 hours after hatching (partly helped from shell).

B 2. 5/26; no development.

C. 6/5; data later rejected (by the author).

D 1. 6/19; no development.

D 2. 6/21; dead at 9 days after hatching.

E 1. 8/2; no development.

E 2. 8/4; no development.

I 1. 2/15/01; no development.

I 2. 2/17/01; no development.

?J 1. 3/4; dead, 19 days after hatching.³

J 2. 3/6; no development.

σ^7 F 1. 10/24; dead 18 days after hatching.¹

F 2. 10/26; no development.

G 1. 11/20; no development.

σ^7 G 2. 11/22; dead 14 days after hatching.²

H 1. 12/30; no development.

H 2. 1/1/01; no development.

K 1. 4/5; no development.

K 2. 4/7; “formed only a circle of blood.”

L 1. 4/20; no development.

L 2. 4/22; dead 10 days after hatching.⁴

(G 5, A 14)

¹ “F1 remained healthy and strong, and I was greatly surprised to find it dead on the morning of Nov. 28. I can not imagine the cause unless some organic defect that appeared quite suddenly as a result of the development, and not of disease.”

² “The bird did well until the morning of Dec. 22, 1900, when I noticed the vent soiled with a greenish discharge, and concluded the bird was fated to die soon. I gave it a tonic tablet, and watched it. It grew worse rapidly and at 10 o'clock I found it dead.”

³ “The bird appeared perfectly well the day before he died and was well fed. * * * The sex = ? I could not discover any sexual organs.”

⁴ “On the evening of May 18 I noticed the bird was wet about the anus. This watery discharge, in some cases greenish, is a sure precursor of death.”

TABLE 64.

Series I—Continued.

♂ *C. guinea* (1).

♀ Owl-rock hyb. (C 1); 1/19/01.

A 1. 6/18/01; no development.

A 2. 6/20/01; no development.

B 1. 7/14; no development.

B 2. 7/16; opened 7/31 (too soon) a live embryo.

C 1. 7/31; died about 7 days after hatching.

C 2. 8/2; died about 7 days after hatching.

D. 9/1; broken (not sure about second egg).

E 1. 10/1 one dead about 8 days after hatching.

E 2. 10/3 one dead about 5 days after hatching.

G 1. 2/16/02; thrown from nest.

G 2. 2/18/02; thrown from nest.

H 1. 3/27; not hatched.

H 2. 3/29; not hatched.

I 1. 4/23; dead at 10 days after hatching.

I 2. 4/25; some development.

J 1. 7/1; no development.

J 2. 7/3; no development.

K 1. 9/25; dead at 7 days.

K 2. 9/27; no development.

L 1. 10/27; no development.

L 2. 10/29; no development.

F 1. 1/15/02; no record, ? no development.

F 2. 1/17/02; no record, ? no development.

♂ *C. guinea* (1).

♀ Owl-rock hyb.; (of 1902); black-chequered.

A 1. 4/26/03 } one, no development; other dead at 12 to 13 days.
A 2. 4/28/03 }

B 1. 5/16; no record.

B 2. 5/18; no record.

C 1. 7/13; dead at 7 days.

C 2. 7/15; probably no development.

D 1. 8/15; no record (? no development).

D 2. 8/17; no record (? no development).

♂ *C. guinea* (1); (escaped April 1904)♀ *C. tabellaria*; (1903); 2-barred.

♂ A 1. 3/20/04; (1); lived till June 1905; disappeared at 15 months; mated with a homer, but no eggs laid.

A 2. 3/22/04; no record, probably no development

(G 5, A 14)

TABLE 65.

Series II.

♂ *C. guinea* (2); probably imported; no record of death.♀ *C. affinis domestica* (RK 4); medium chequered; died 8/20/01.A 1. 3/30/01; dead at 5 days; healthy day before.¹

A 2. 4/1/01; dead at 5 days; healthy day before.

B 1. 4/14; dead at 14 days "perfectly well at 7 p.m. of this day, sudden collapse a mystery."

B 2. 4/16; dead at 7 to 10 days.

C 1. 5/1 } one, a ♂, dead (cholera) 4/2/02; 11 months; fertile.

C 2. 5/3 } one, a ♀, alive 11/10/03; 30+ months; not fecund with sire (see text-fig. 8, page 217.)

D 1. 6/1; dead at 5 to 7 days.

E. 7/13; developed (opened prematurely).

D 2. 6/3; dead at 5 to 7 days.

F 1. 7/28 (0); "dead at few days" after hatching.

F 2. 7/31; egg laid late; no development!

♂ *C. guinea* (2).♀ *C. guinea* × *domestica* hyb. (C) of 5/2/01. } This sire and daughter mated Dec. to Mar. 16, '02, but laid no eggs!♂ *C. guinea* (2).

♀ Owl × rock hyb. (pale-chequered).

A 1. 4/3/02; no development.

A 2. 4/5/02; dead at 7 days.

C. 6/7; no development.

B 1. 5/4; dead at 10 days old! (best of care).

D 1. 7/12; dead at 7 days.

B 2. 5/6; no record; probably no development.

D 2. 7/14; dead at 7 days.

Birds separated winter 1902-3.

E 1. 3/29/03; no development.

E 2. 3/31/03; no development.

G 1. 5/23; no development.

G 2. 5/25; no development.

I. 7/12; no record(=? no development).

F 1. 4/16; no development.

F 2. 4/18; no development.

H 1. 6/?; no development.

H 2. 6/?; no development.

(P 3, A 14)

♂ *C. guinea* (2).

♀ Owl × rock hyb.; (2 years old when placed here); dark chequers.

A 1. 3/24/04; no development.

A 2. 3/26/04; no development.

¹ "First time both eggs in such a cross have hatched. Age at death = A 1, 5 days; A 2, 5 days."

TABLE 65 (continued).

A fifth female, a homer (*C. tabellaria*, then in second year) given to this male on 5/7/04; this same homer mated earlier in 1904 with *C. guinea* (1) producing 2 eggs before:

♀ A 1. 5/12/04.....(2).....	hatched, alive May, 1905.....	12+ mo.
♀ A 2. 5/14/04.....(3).....	hatched, matured, mated with homer, alive Dec. 1905.....	20+ mo.
B 1. 7/4;	no development.	
B 2. 7/6;	no development.	
♀ C 1. 7/28.....(4).....	dead 5/29/05.....	10 mo. (confinement 7).
♂ C 2. 7/30.....(5).....	dead 8/12/05.....	12½ mo.; fertile with homer.
♀ D 1. 10/10.....(6).....	dead 5/25/06.....	19½ mo.
♂ D 2. 10/12.....(7).....	dead 6/22/06.....	20½ mo.

This ♂ tested (for sixth time) with his daughter—a ♀ guinea × homer hybrid (2); their eggs of 4/13 and 4/15/05 were incubated, but neither showed any development.

TABLE 67.—Male guinea-homer hybrids back-crossed to homers.

♂ Guinea-tabellaria hyb. (1); 3/20/04; disappeared June 1905.

♀ *C. tabellaria* (C 2—3); 3, 13, 01.

A 1. 3/11/05; "hatched, with help, after 19 days, 20 hours; lived 1 day, too weak to feed."

A 2. 3, 13 05; "little or no development."

B 1. 4/8; no development.

B 2. 4/10; no development.

C. 5/11; no record; probably no development.

♂ Guinea-tabellaria hyb. (7); 10/12/04; 6/22/06; 20½ mo.

♀ *C. tabellaria* (C 2—3).

AA 1. 6/29/05 } from another sire, not (7); both eggs hatched.

AA 2. 7/1/05 }

♂ B 1. 7/29;.....G7B.....mated with a homer; dead 7/30/06.....12 mo.

♀ B 2. 7/31;.....G7B.....mated with a rock.

C 1. 9/15;.....G7C.....disappeared 11/?/05.....2+ mo.

♂ C 2. 9/17;.....G7C.....alive 5, 6, 06.

Other eggs laid and hatched; not sired by hybrid (7), except 1 in 1906.

G. 5/15/06;.....G7G.....dead at 7 days.

♂ Guinea-tabellaria hyb. (5); 7/30/04; 8/12/05; 12½ mo.

♀ *C. tabellaria* (A) from fancier 1905; chequered.

A 1. 4/17/05; deserted.

A 2. 4/19/05; deserted.

B 1. 5/11; hatched, dead at 12 days (cold?).

B 2. 5/13; some development.

♀ C 1. 6/28;.....C5C.....alive Nov. 1906.....17+ mo.

C 2. 6/30; hatched; dead at 23 days. (P 4)

TABLE 68.—Female guinea-homer hybrids back-crossed to common pigeons.

♂ *C. tabellaria* (9) 1904.

♀ Guinea-tabellaria (3); 5/14/04; alive 20+ mo.

A 1. 3/25/05; no development.

A 2. 3/27/05; no development.

C 1. 5/12; no development.

C 2. 5/14; no development.

E 1. 7/?/05; no development.

E 2. 7/?/05; no development.

B 1. 4/17; no development.

B 2. 4/19; no development.

D 1. 6/17; no development.

D 2. 6/19; no development.

F 1. 12/17; no development.

F 2. 12, 19; no development.

♂ *C. tabellaria* from fancier 1905.

♀ Guinea-tabellaria (6); 10/10/04; 5/25/06; 19½ mo.

A 1. 7/9/05; no development.

A 2. 7/11/05; "circle of blood."

B 1. 1/22/06; one, no development.

B 2. 1/24/06; one, a little development.

♂ *C. domestica* (7).

♀ Guinea-tabellaria (4); 7/28/04.

A 1. 5/7/05; one no development.

A 2. 5/9/05; other a little development.

(P 4)

TABLE 69.—*Matings of secondary guinea-homer hybrids.*

♂ Guinea-tabellaria × tabellaria (G7C); 9/17/05 (brother).

♀ Guinea-tabellaria × tabellaria hyb. (G5C); 6/28/05 (sister).

A 1. 5/20/06; no record, probably no development.

B 1. 9/12; no development.

A 2. 5/22/06; no record, probably no development.

B 2. 9/14; no development.

♂ { C 1. 10/25 } one ♂ G7C-C, mated with homer (hatched 2 young), dead 6/27/09 = 32 mo. (pl. 54, Vol. I.)
 { C 2. 10/27 } one no development.

♂ Guinea-tabellaria × tabellaria hyb. (G7B); 7/29/05; 7/30/06; 12 mo.

♀ C. tabellaria.

A 1. 4/17/06. G 7 B-A¹. dead 7/30/06. 2½ mo.

A 2. 4/17/06. G 7 B-A. dead or disappeared before 5/20/08.

B 1. 5/24. G 7 B-B. dead or disappeared before 5/20/08.

B 2. 5/26. G 7 B-B. dead or disappeared before 5/20/08.

♂ (¼ guinea, ¾ tab.) G 7 C-C of 10/26/06 of the mating above; mated early 1908.

♀ C. tabellaria; escaped 5/20/08.

♂ A. 3/15/08. G 7 C-C-A. dead or disappeared before 2/5/11 (pl. 54, Vol. I).

♂ B. 4/21/08. G 7 C-C-B. mated w. homer (K 4) = 1 young; escaped 3/27/09 = 11+ mo. (pl. 54, Vol. I).

♀ C. tabellaria (K 4) given to this ♂, 1909.

♀ A 1. 4/25/09; dead 7/13/11; 27 mo.

A 2. 4/27/09; hatched; no record of death.

B 1. 6/1; sick; killed at few weeks or months.

♂ B 2. 6/3; dead 9/11/11; 27 mo.

(P 4)

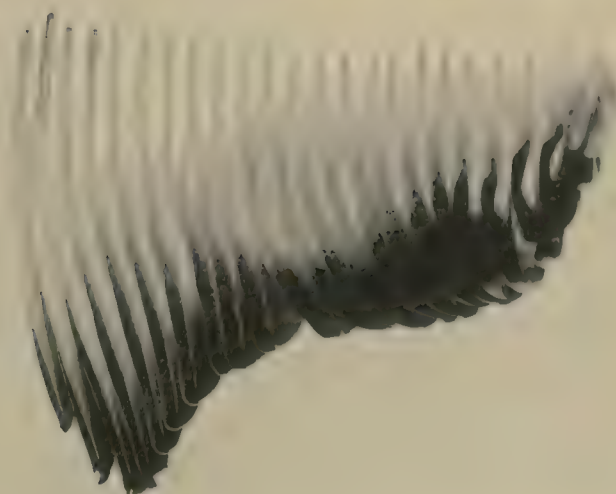
¹ Where two birds were given the same tag numbers (as here) the birds were distinguished by the tag being on right or left leg.—EDITOR.



A



B



C



D

Common pigeon hybrid (5-E2, from common X homer) with whitened bars from early breeding. Hatched June 4, 1909; age 6 weeks. The sire of this bird was 6 months old; the dam about 7 months old. Figs. B and D show the nature of the whitening, in particular feathers plucked when the young was 7 weeks old.

A. General coloration and whitening in the wing.

B. The expanded tail.

C. The primaries, secondaries and tertials.

D. The first row of wing-coverts.

CHAPTER IX.

BREEDING AND INBREEDING FOR COLOR IN SOME DOMESTIC PIGEONS.

In the mating of individuals of essentially the same breed of common pigeons there can sometimes be obtained evidence that white and red color tend to appear mostly in the later offspring of the season. From the very first effort of the season also, particularly when immature birds are used as parents, these colors are relatively frequent. "Weak germs" are equally responsible for the white or red in both cases. In many cases these striking color variants show other abnormalities or marks of physical degeneracy. The several agencies or factors other than season which similarly affect color, fertility, and sex are also prominent in some of the several series of matings brought together here. Fortunately, the author has written rather fully of the causes of weakness of many of the offspring of these matings; throughout this chapter these statements by the author are given the form of quotations.

The common pigeons most studied were homers, barbs, pouters, owls, and common rocks. Three or four crosses of these forms with nearly related wild species have been added for the sake of completeness and in order to supply the original data for the fertility and sex summaries of Chapter II. It need scarcely be remarked that here, as elsewhere, all of the data available, not a selected part of it, is presented.

COLOR AND WEAKNESS IN HOMERS.¹

The results of mating a pair of common pigeons during a part of 3 years are presented in table 70. The last pair of eggs, from each of the two included autumns, hatched birds with much more of white color than was present in any of the birds hatched from the earlier part of the season. Two of these young are shown with their parents in plate 14. The whitened birds of the second autumn were followed in the succeeding year by birds of normal color. The very earliest egg of the second season, moreover, hatched a bird (No. 5) of fairly normal plumage, but its weakness was revealed by breeding. This male *E 1* (or No. 5, hatched January 15, 1909, of the progeny of table 70), was mated in May 1909 with a female homer, hatched November 15, 1908. It will be noted that this male came from ♂ red guinea × ♀ black guinea, and that, as stated by the author, "both of its parents were *strong*² birds; but this *young* male (5) had one white primary and three white primary coverts (the latter in both wings), and came at the *beginning* of the season of 1909. At the time of getting his *first* young this male had, therefore, nothing to indicate weakness, except that he was only *6 months old*. His breeding power should be highest at the age of 3 to 6 years. The female (*E*) with which *E 1* was mated came from an old but strong homer (a few chequers). Her dam was a light gray *two-barred* homer, that had one drooping wing affected with *tuberculosis* in the joint. The points of weakness in the dam of *E* were, then, *lateness in season* and *tuberculosis*, difficulty in flight, and death in May following.

¹ A mating of mongrel common pigeons whose progeny were crossed with homers is more conveniently presented here than elsewhere.—EDITOR.

² It is elsewhere noted that this bird (and some of her brothers and sisters) had "frills" in some feathers of the wing (pl. 71, Vol. I) and that this often accompanies weakness.—EDITOR.

"The points of weakness in the daughter (*E*) were shown especially in the *obsolescent* bars, the right second bar being scarcely more than a shadow of a bar, and again in her *young age*, being only about 7 months old. Her nest mate was a *sister* (also No. *E*), and *two females*³ from a clutch show weakness in parents, and weakness in parents leads us to expect it in the young. Furthermore, this dam was hatched November 15 from an egg laid at the *end of October*—at a time of lowest energy in the parents." (XG 24, R 16)

This pair of weak parents produced the following:

- A 1. (5 E 1) hatched 6/4/09; dead before 2/1, 11; moderately chequered, black without white.
 ♀ A 2. (5 E-2) hatched 6/4/09; dead on 10/15/09; whitened (see pl. 15).

When 6 weeks old the second young (A 2 or 5 E-2) was examined, photographed (pl. 15) and described. White color was in evidence; the two dark bars present were invaded by white advancing from the feathers' tip. "This whitening of the bars of the young was the result of *parental weakness*" (R 16). At the same time, feathers were plucked to learn the color of a second plumage.

"On October 15, 1909, 3 months after plucking, the bird has made but very little progress in moulting. The plucked secondaries have been replaced, but still show white to about the same extent as before. The outer primaries (5 or 6 of them) have not yet come out, and apparently they are at a standstill. The right wing still remains intact and not more than half a dozen juvenal feathers have been moulted. The bird seemed drooping or sick for a week or two before death on the above-named date, but has had a good pen and good care. I find that the tail feathers have been replaced and have come out with the original amount, or very nearly, of the *white*. It turns out to be a female. The liver was somewhat blackened, and the intestine was swollen and full of watery contents. The early death again testifies to *physical weakness*. The result—whitened bars and whitened tail feathers in the offspring⁴—is thus well accounted for without the aid of specific determinants." (XG 24, R 16)

The first mating of pure homers to be described involves a male homer (Hom. 1) whose fertility had previously been tested with birds representing three different genera, all of a different family from that to which the homer belongs. This male had successfully produced young with two of these genera, and had failed to fertilize eggs (4 tests) of the most modified or divergent⁵ of these 3—the crested pigeon of Australia. After these tests of his fertility he was mated with a homer (Hom. 3), and still later with his daughter. Varying degrees of fertility (reduced in all) were shown in the family crosses with the various genera used—*St. risoria* (*M* 2 and *F* 2), *T. orientalis* (2), *Ocyphaps lophotes* (*Cp*). When this bird was paired with his own kind practically all eggs were fertilized; with his daughter also he was fully fertile.

This "fairly strongly" chequered and highly fertile male was mated with a strongly chequered (dark) female to see if birds darker than either parent might be

³ The italics of this entire quotation (this and the two following quoted paragraphs) are those of the author. Almost everywhere, in the author's later manuscripts which deal with breeding, one finds a word or two on the immediate particular factor or factors associated with a particular group of weak germs. Probably nowhere better than in these paragraphs has he written of a number of them at once.—EDITOR.

⁴ "Horwood (*Nature*, June 11, 1908, p. 126—Coloration of Bird's Eggs) notes that, 'The *intensity of coloration* varies with age up to a certain point. Eggs of young birds are often unspotted. Absence of markings is doubtless due to deficiency of pigmentation. The last egg or eggs of a second brood, in fact, often lack normal coloration or markings.' *Age and health* thus control the coloration, which is brilliant in a healthy but indistinct in an unhealthy bird's egg." (R 16)

⁵ See Vol. I, table 2, etc.

obtained. It will be seen by reference to table 71 that *lighter* but not *darker* birds resulted. Nine young were certainly intermediate to the two parents in color. Two were as dark as the darker parent, two were similar to the lighter colored parent, and four —“plus the several birds raised by Ollson during the winter of 1900-1—had only gray color with two black bars.” The number of offspring of lighter color than either parent was therefore probably between 9 and 12. The two sexes are known to have been represented in nearly all of these various groups. It is also notable that the *greater number of these lightest colored individuals were from the weakened germs of autumn and winter.*

Adequate color descriptions can be found for only two of the offspring of the sire \times daughter mating. One was as light as the lighter parent, the other was intermediate.

Two of the very darkest of the offspring (of homers 1 and 3) were mated, brother to sister, to see if their dark color might be increased to pure black. It will be seen that progress in this direction—by *inbreeding*—was not accomplished.⁶ On the contrary, unexpected *white* and *red* appeared, as did also *asymmetrical* developments in the first 3 offspring of these very young parents. Only 6 offspring were probably as dark as the parents. The young whose color throughout was as dark as that of the parents were from eggs laid February 20, 1902; April 3, 1902; May 12 and 14, 1902; February 2, 1903; April 15, 1903; and June 4, 1903. It is therefore clear that more whites and reds and more defectives arose when the parents were very young and from eggs laid late in the season.

The *inbreeding* of the young (of homers 1 and 3) was further carried out as follows: Two of the offspring⁷ of the above pair produced 8 young for which we have some data.⁸ Here it is notable that the first pair of eggs of which we have a record threw birds which were gray with only two bars; and that each of the three succeeding clutches contained a bird with *red* chequers. (BB 9)

♂C 1. hatched March 5, 1901; even gray, 2-barred.

♂C 2. hatched March 6, 1901; gray, 2-barred.

“This pair, then (after the two young listed above), produced three successive pairs of young, each time *one black-chequered* and *one pale red-chequered.*” The latter hatched as follows:

(1) ♀ hatched about May 15, 1901; died May 5, 1902.

(2) — hatched about June 20, 1901; died September 15, 1901.

(3) — hatched about August 8, 1901.

One of the above gray 2-barred males (C 1) was mated in 1902 to a related homer. This related female (C) was from the mating recorded in table 76, this latter bird being a sister to both parents of C 1. It will be seen (table 73) that the further inbreeding of the pair now under consideration gave only 2-barred and 2-reddish-barred offspring, with some infertile eggs.

The further inbreeding of two of the young from the brother-and-sister mating described in table 72 brings out much more forcefully the effect of inbreeding upon the developmental strength of germs. Only in their second (and third?) year

⁶ For further statement on this “selection experiment” see Chapter II (and illustrations), Vol. I.

⁷ ♂B 1 and ♀A 1, via K 1 and J 2, from eggs December 28, 1900, and October 26, 1900, respectively.

⁸ The complete record of this mating can not be found. The above data are taken from scattered statements and the one much-abridged summary given above in the author's words.

were the germs of these birds capable of any development. The early part of the season, after a long rest, too, was the time of greatest fertility. Not a single young was reared from 28 tests (table 74).

It was shown above that a selection of the blackest progeny of dark homers for brother-and-sister matings did not lead to the production of darker progeny, but to a majority of offspring of lighter or redder color than parents or grandparents; it was indicated also that weakening effects (inbreeding, etc.) were responsible, in part at least, for this result.

The reverse of the above experiment was also studied. In this experiment light-colored homers (few chequers and small bars) were selected as parents in an effort to obtain offspring of still lighter color. This effort was successful (Chapter II, Vol. I). Table 75 shows, however, that it succeeded best when sire (darker of original parents) was mated to daughter (lightest and narrowest bars), and from eggs laid late in the autumn (August and November); 3 of the 4 eggs then produced gave rise to birds with weaker bars than had any of their known ancestors.⁹ This situation, moreover, was continued in the succeeding germs which were laid "out of season." Two photographs (pl. 16) assist in making clear the measure of success attained in this experiment. In the first mating listed in table 75 the parents were unrelated; the lightest colored young of this mating developed from eggs laid outside of the usual breeding season, during autumn and winter.

Another mating for a period of 5 years was made in the effort to produce 2-barred homers from 3-barred parents one of whom had chequers as well as 3 bars.

⁹ The fourth had bars equal to the least developed bars of a parent, and was of lighter color.

EXPLANATION OF PLATE 16.

A. Two juvenal homers, brother and sister to the pair figured below. Hatched from a clutch (*H 1* and *H 2*) just preceding young of fig. B; also the parents of these two pairs of young.

On the extreme left is *H 1* in juvenal plumage; it presents another distinct step towards the complete obliteration of the bars of the wings and also of the tail. This bird has a typical homer build or form, but has a single feather turned outward (frill-like) in the middle of the upper breast. The ground-color is a distinct shade lighter than the ordinary rock-gray. Head and neck decidedly lighter than in rocks, a shade of rusty brownish in the neck. In place of the subapical black band in the tail there is a very pale whitish-gray band, about 17 mm. in width, with an apical dusky-gray border about 7 mm. in width. Rump whitish gray.

The wing-bars have lost the black almost wholly, leaving a paler gray than in the rest of the wing; and this paler gray is lightly touched with brownish and bordered posteriorly with a narrow, ill-defined dusky line, varying from 1 to 2 mm. in width. Both bars are in essentially the same condition, but we may note that in the posterior bar the black is practically a faint trace of brownish. In the tertials this posterior bar is nearly of the same color as the anterior bar, but on the inner 3 or 4 tertials 2 to 3 dusky "fundamental bars" cross the outer web of the feathers. *This bird makes a near approach to complete loss of wing-bars.* At a little distance it appears to have no bars, or only shadowy indications of lost bars.

On the extreme right is *H 2*; it is clear rock-gray in color, and has narrow black bars about the same as its mother. It has the usual subapical tail-band; the rump is white. The anterior bar has a width of 9 mm. on the inner coverts and gradually narrows to 5 mm. just below the middle of the row of coverts. The posterior bar (on 6 inner tertials) has a greatest width of 17 mm. on the fourth tertial; it becomes freckled with gray on the seventh tertial and is nearly obliterated on the eighth.

The two parents are shown at the center of the figure.

B. Juvenal homers (*I 1* and *I 2*) with light color (in *I 1*) and with wing-bars reduced. Photographed Jan. 19, 1910, at the age of 6 weeks 4 days.

These birds from sire mated to daughter (table 75), and from eggs laid in very late autumn, Nov. 15 to 17, 1909.

Juvenal *I 1* (on left) has rock-gray color with four squarish black spots on the outer web of the inner tertials. The first and fourth spots are a little smaller and weaker or thinner than the second and third, which measure 10 by 8 mm. and 13 by 8 mm., respectively. Below these spots there are only scattered freckles which are too weak to figure as spots. The appearance is thus practically what we see in the stock-dove (*C. anas*). The anterior bar has no spots, but just freckles enough to indicate a trace of a bar when closely examined.

Juvenal *I 2*, color almost white or silver gray.

A



B



- A. Homers, brother and sister to the pair figured below. Hatched from a clutch (*H 1* and *H 2*) just preceding the pair shown in the lower figure; also the parents of these two pairs of young.
- B. Juvenal homers (*I 1* and *I 2*) with light color (in *I 1*) and with wing bars reduced. Photographed Jan. 19, 1910, at age of 6 weeks 4 days.

The color records are adequate, or nearly so, in the cases of 22 young. They fall into the following groups: Intermediate, 12 (+?4); lighter than lighter parent, 5 (+?2); darker than darker parent, 1; infertile 4. The seasonal distribution of these very light colored birds is of chief interest, and an examination of the appended table (76) shows that 4 of the total of 5 arose from the first or the last clutch (hatched) of the year; the other very light colored bird hatched from the last clutch of which we have a record in 1904. The four eggs that failed to develop were all from the extreme end of the year. Three of these lightest colored offspring are from the two clutches immediately adjoining a pair of infertile eggs.

Still another of the offspring (marked *F 1*) of the mating ♂ *B 1* × ♀ *A 1* was mated with a consort that seems¹⁰ to be *I 2* (from egg of January 24, 1900) of homers 1 and 3 (see table 71). The parents of *I 2* are therefore at the same time all of the grandparents of *F 1*. *F 1* was gray with 2 bars; the female *I 2* was chequered a little less than her least chequered parent (Hom. 3). Only 4 eggs are recorded, but it is of interest to note that the first pair (Feb. 3 and 5, 1900) of these (also ?first in life) were incapable of hatching, and that the second pair of eggs (Mar. 5 and 7, 1900) both hatched birds with the reduced barring—2 bars, without chequers. (BB 9)

Records were kept for a few other pairs of inbreeding homers, but those pairs were not confined to a cote; and since such females might secure fertilization from other males (as noted by the author), all such pairings have been excluded from consideration in these pages.

BLACK, RED, AND GRAY BARBS FROM BLACK PARENTS.

The following experience with black barbs (a domestic variety) indicates that the sliding scale of fertility elsewhere elaborated is accompanied by a change or reversal of the dominance of color. The dominant black becomes but partially dominant under a series of conditions that weakens germs, *i.e.*, inbreeding, late season, and immaturity of parents (possibly also, second egg of the clutch). Red and gray colors appear under these conditions, as will be seen by an examination of the data of tables 77 and 78.

A red male (*K*) from these black barbs was mated in 1906 with a red-and-white barb. It is certainly interesting, in view of the foregoing situation, that this immature red male mated to a (possibly immature) red-and-white bird should throw nearly or quite as many black as red, whereas the several inbred black barbs mated to other black barbs threw nearly as many non-black (red and gray) as black; and indeed a much higher proportion of non-black in the periods of "weakest germs." These data are included in table 78.

In all of the above matings where more than one color appeared, it will be observed that there hatched 15 black, 11 red, and 4 gray. But in spite of this predominance of black (even where black was not the *exclusive* or only color), the last egg of the season was never known to produce a black, though 3 such threw red and 1 gray (2 did not develop). And, further, where two colors appear from a single clutch the second egg never produced the predominant black, though the rarer red bears such a relation in three cases. It is not surprising to find black

¹⁰ In this case the editor is not positive that he has the right history of the birds concerned in the mating. It is probably right as stated.

barbs throwing some red and some gray offspring; the importance of these data lies in the suggestion that these colors arise from the "weaker germs," and in the evidence furnished by this group for the genetic non-equivalence of the two eggs of the pigeon's clutch.¹¹ It is clear that the color of the red birds at least is not changed secondarily through a change of sex, since birds of both sexes were of this color.

PHYSICAL DEGENERACY AND RED-AND-WHITE COLOR ASSOCIATED WITH LATE SEASON AND WITH INBREEDING IN GRAY BRÜNN POUTERS.

A few gray Brünn pouters were bred for two or three years. The number of pairs and the number of young are not large. The results, however, clearly support other data indicating, (a) that the first egg of the season and the autumn eggs are "weak" germs; (b) that white and red colors and physical degeneracy are here associated with the periods of "weak" germs; and (c) that in inbreds degeneracy and red and white colors readily appear. The data for (a) and (b) were obtained from a mating in 1908-9, and are fully given in table 79. The female of this series hatched 12 young in 1908. The colors of the first, eighth, ninth, tenth,¹² and twelfth (Nov. 11) of the season showed weakness of coloration (red or white). The eighth, ninth, and tenth (late autumn) show unusual red or white; the tenth

EXPLANATION OF PLATE 17.

- A. Juvenal pair (*C 1* and *C 2*) of gray pouters from a brother-and-sister mating (pair 3 of table 80). Photographed at 7 weeks.

C 1 (to the left) was of nearly normal color (see table 80, pair 3).

C 2 (to the right) is quite a departure; it is *practically white-barred throughout*, i.e., every row of feathers on the wing is white, broadly tipped with brown orange. The bird has variegating legs to some extent and is a weakling, though not conspicuously so in other respects than the excess of white color and leg variegation. It has a white band in the tail and "frills" in the tertials.

- B. Juvenal pair (Nos. 8 and 9) of pouters from gray (white-barred) parents; 12 weeks old (see table 79).

The great unlikeness of the two young is shown. The one (No. 9) was white, and was unable to fly. The primaries were not well developed and were not closed, but hung at many angles. The legs sprawled apart, so that walking was very awkward. The bird ate well, but had a very shaky behavior; the head-movement was not normal but shaky, as in high-bred fantails. The bird was a degenerate. The mate (8) was a fine, sleek bird, well developed and perfect in feather, but also a degenerate in color and in failure to lay eggs. When adult the red-black wing-bars (shown in the illustration for the juvenal) turned to white with black borders, but retained a tinge of red. The latter bird is higher in development than the former.

EXPLANATION OF PLATE 18.

- A. Adult gray pouters (son and dam; see table 79) and one of their offspring (*J*, Aug. 5, 1909; see table 79) in juvenal plumage.

The sire and dam (to right and left) are similarly and normally colored.

The young bird (*J*) stands in the center. The photograph was taken at 7 weeks and shows the rock-gray color and presence of two black bars.

- B. Adult gray pouters (male No. 4 and female No. 6 of table 79), and two of their color-modified offspring (*E 1* and *E 2* of August 9 and 11, 1909; see table 80). Photographed Oct. 16, 1909; the young at 7 weeks old.

The adult male stands to the left (front); the female stands behind the male.

E 1 is at the extreme right. The color of this bird is rock-gray with two black bars.

E 2 is at the center. This bird is red throughout; there are no wing-bars, and the bases or proximal parts of the feathers are whitened.

¹¹ Unfortunately the relative *weights* of these eggs is unknown; in many (or most?) domestic pigeons the usual order (for wild species), for both size and prospective sex, is maintained quite loosely or not at all.—EDITOR.

¹² The numbers in the table are tag numbers given to the birds. The second bird hatched was given no number; therefore "ninth" and "tenth" above correspond to birds numbered (8) and (9).—EDITOR.

A



B



- A. Juvenal pair (*C 1* and *C 2*) of gray pouters from a brother-and-sister mating (pair 3 of table 80). Photographed at 7 weeks.
- B. Juvenal pair (Nos. 8 and 9) from gray, white-barred parents; 12 weeks old (see table 79).

A



B



- A. Adult gray pouters (son and dam, see table 79) and one of their offspring (*J*, of Aug. 5, 1909; see table 79) in juvenal plumage.
- B. Adult gray pouters (male No. 4 and female No. 6 of table 79), and two of their color-modified offspring (*E 1* and *E 2* of August 9 and 11, 1909; see table 80). Photographed Oct. 16, 1909; the young at 7 weeks old.

(9 in table) being practically pure white. These birds are shown in pls. 14 and 17. Another striking color variant of another type, from the following summer, when the dam was mated to a normal son, is shown in pl. 18. Two normally colored young, the fifth and seventh of the series of 1908, may be seen in pl. 18.

The first, ninth, and tenth of these young gave still other evidences of physical degeneracy. A mating of the first young of the series, a female gray pouter (1), with a male black pouter produced but a single pair of eggs (no record of hatching); three abortive attempts at egg-laying show, however, that this female, from the very first egg of the season, was a degenerate; the red bars of her adult plumage indicate the same.¹³ (G 16)

Two of the sisters of this bird, from very late in the season, were also degenerates. Concerning this pair the following statement is found:

"Degenerates ♀ 8 and ♀ 9: Female 8 was hatched October 10, 1908. She is dark gray, having bars *red* with *black* border. A neat bird but a degenerate as shown by color, and by her failure to produce an egg March 6, 1909, when mated with a strong male black pouter.

"Female 9 hatched October 11, 1908—*white*! Her feathers were slow and very irregular in growth; she was never able to fly, but lived until January 27, 1909. She was kept in the house and well cared for, and there was no cause for death but weakness. The legs of this bird sprawled, so that walking was difficult; her motions were very shaky, the head shaking like a fantail; the primaries hung loosely apart." (G 16, R 16)

These birds are shown in pl. 17.

Several other pouters of the same series (hatched in 1908) were mated brother-to-sister during the following year. The records of 3 such pairs is given in table 80. In 1909, pair 1 threw, from the last clutch of record, a bird with deficient pigmentation and "diverging legs." Two normal birds had preceded it. Only a single clutch of eggs was laid (March) during the following year. The bird from the first egg here had white wing-bars and was too lightly pigmented; that from the second egg had black bars with traces of red. Pairs 2 and 3 of these brother-to-sister matings each threw a solid red or red-orange bird as their final effort in the late season; in pair 3, which bred latest (until September), both eggs of the last clutch showed red, though one of these had red only in the region of the normally white bars (see pl. 14). An earlier clutch produced one bird of normal color, and one with nearly all feathers "white" with broad tips of "brown-orange." This bird also had "diverging legs." Both young from this clutch are shown in pl. 17. The abnormally colored young from the last eggs of pair 2 are shown in pl. 18. Besides the red-colored young mentioned above, another of the rock-dove type was produced from the first egg. The two strongly abnormal young of these two pairs were both from the second egg of the clutch.

The black Brünn pouters listed in table 81 show abnormal "gray" birds (with the white bars of the black parents replaced by the black bars) from both of the latest laid eggs. The 4 birds from the second year of this mating all seem to have had their white bars more or less replaced by red or black.

¹³ "These birds mated about February 1, 1909, and were given a separate cote. They copulated, built a nest, and, although laying no egg, began to sit on empty nest early in March. They were allowed to continue sitting, which they did for about 2 weeks. Later, after leaving the nest for about a week, they returned to it as if to begin a second turn. This time also no egg was laid, and the sitting continued for only about a week. A third attempt was made in April, but without an egg. About May 1 and 3 they began to build the same nest in the same place, and at length, on May 9, the female laid her first egg! As this female was hatched May 2, 1908, she should have succeeded in producing an egg early in the winter. To have failed several times, up to May 9, shows that she is a degenerate." (G 16)

COLOR IN OWL \times ROCK CROSSES.

Three separate matings of African owls (*Columba turbata dom.* var.) with domestic rock-pigeons¹⁴ (*C. livia dom.*) seem to show that color is here sex-limited in its inheritance. The editor finds no comment on the data, which are presented in full (tables 82 to 83A). The reader will readily see, however, that young of two colors are produced and that all of the known females were of the light "owl" color, and that all known males were of dark color.

Two pairs of owl \times rock hybrids were inbred. From pair 1, 3 red offspring were obtained in late season and "out of season" (table 84). This case further illustrates the point, elsewhere mentioned by the author, that a commingling of colors quite often produces red, though neither parent nor grandparent exhibited this color. The second pair was composed of the male of the preceding pair mated to his half-sister. Though this female showed traces of "brown" in the chequered parts of her wing, neither of the resulting 6 offspring was red. In this case also, however, the last clutch of the season produced two birds of the lightest color present in the series. It may be pointed out that there are three obvious reasons why one should expect fewer red offspring from pair 2 than from pair 1: (1) the degree of inbreeding is less; (2) the eggs were produced from a better part of the season; and (3) the mother of the female of pair 2 was darker than the mother of the dam used in pair 1. Females of dark and of light color appear in the F₂ generation.

FERTILITY AND SEASON IN CROSSES OF COMMON PIGEONS WITH FERAL COLUMBÆ.

A few data are available on the crosses of the stock-dove (*Columba ænas*) and the wood-pigeon (*Columba palumbus*) with domestic pigeons. In the single record for the stock \times domestic cross a complete failure of fertility is found in the late autumn (table 85). The young produced from the stronger germs of the season nearly all died early, but this was the result of their feeding and is probably not otherwise significant. One of the male hybrids was fully fertile with *C. livia dom.*, and the author notes, of the last young of the season (table 86), that "color here seems to be that of the earlier hatched young."

A cross of *C. admista dom.* \times *C. palumbus* proved remarkably infertile (table 87); but since only a single female was tested, this cross may be more fertile than is here indicated.

Two common pigeons obtained in the autumn of 1910 from a fancier yielded, during the autumn, but two clutches of eggs. Developmental power was then at a very low point, as is shown by the complete failure of the last clutch (October 7 and 9) to develop, and by the production from both eggs of the earlier clutch (September 17 and 19) of "two young with much white."¹⁵ The male was a brunette—quite black. The dam was red with white primaries and with the so-called "guineamark," i.e. a small triangular white tip to many of the feathers (G 9). The dates of the death of the parents, the male before February 15, 1911, and the female on August 18, 1911, is a further evidence of weakness in these birds at the time they gave rise to the "whitened" young.

¹⁴ It will at some time be of interest to note the order of the sexes from eggs of *C. livia dom.* Within the individual clutches of these birds the order of sexes from the eggs varies greatly from the order known for most pure wild species; the first egg here often gives rise to a female, the second often to a male; and studies by the editor have further shown that the size relations of the yolks of the two eggs of the *C. livia dom.* clutch are similarly variable.

¹⁵ These birds were photographed October 14, 1910, but copies or plates are not available to the editor.

BREEDING DATA ON WILD ROCK-PIGEONS.

Chiefly in the interest of a complete presentation of *all* of the breeding data for the common pigeons and the related (ancestral?) forms, tables 87A to 87D have been prepared.

Concerning a mating (table 87A) of a wild *C. livia* with a domestic pigeon of similar appearance (*C. livia dom.*) the author makes the following statement:

"I notice in rock-pigeon hybrids obtained by crossing a chequered male (*C. affinis*, from Inishbofin, Ireland) with a two-barred female (*C. livia*, from Dover, England) that the bars in the young are pale, especially the anterior bar. The same is true of these bars in the young (first feathers) of domestic pigeons. In the young of 'pure' rock-pigeons, however, the bars are both 'strong black.' Besides, the gray is pure in the pure-bred; that is to say, it is about the same as in the adults, while in these impure young rocks there is a decided brownish tinge in the gray.

"I infer that weak or pale bars in the first feathers is due to degeneration, the degeneration showing itself first in the juvenal feathers. It is certainly interesting that the pure-bred rocks strike so directly into the adult color."

For the matings of wild rock-pigeons, two-barred and chequered forms, the data of the tables (87B to 87D) are not very complete. The fact that these forms are usually considered to be the ancestors of the numerous races of fancy or domestic pigeons serves, however, to give some value to these records. It will be noted that the chequered rocks (*C. affinis*) obtained from the Cromarty Caves, Scotland, repeatedly threw typical offspring of the two-barred variety.

TABLE 70.

♂ Common pigeon (red guinea-chequers); from dealer 1906 (at about 1 yr. old); has some white primaries; frilled (see pl. 53,
♀ Common pigeon (black guinea-chequers); from dealer 1906 (see pl. 53, Vol. I, also pl. 14). [Vol. I, also pl. 14).

A 1. 7/2/08. hatched dead 7/23/08; cause unknown.

A 2. 7/4/08. hatched dead 7/23/08; cause unknown.

B. 8/1; some development, but unhatched.

♂ C 1. 9/22. (1). hatched; like sire, but more white.

C 2. 9/24. (2). about same amount of white as 1, but more dark gray where it is red-brown.

♂ D 1. 11/7. (3). hatched dead 1/20/09; "considerable white."¹

D 2. 11/9. (4). hatched dead 1/26/09; "considerable white."

♂ E 1. hatched ² 1/15/09-(5); dead 9/5/09; 1 primary white, mostly dark as dam.³
E 2. hatched 1/15/09-(6); no white in wings, mostly dark as dam.

F 1. hatched 3/6; red; with white primaries like sire.

F 2. hatched 3/7; killed; fall from nest.

G 1. hatched 4/3.

H 1.; no record.

I 1.; no record.

G 2. hatched 4/3.

H 2.; no record.

I 2.; no record.

J 1. hatched about 8/17; very light; "three-fourths, or more white" (see pl. 14).

J 2. hatched about 8/19; very light; "three-fourths, or more white" (see pl. 14).

K 1. 6/2/10; color of black guinea mother.

♂ K 2. 6/2/10; red and white primaries, like sire.

(XG 26)

¹ "D 1 (3) at the age of 6½ weeks has white primaries and white secondaries in each wing. Body white above and below. Outer feather of each side of tail white in outer web, clear up to the (subterminal) bar; upper and lower tail-coverts gray anal feathers white. The wings are blackish (though the 'white apical guinea-marks' are generally increased) with red-brown visible everywhere. White flecks on the head and in the outer front edge of each wing; upper part of legs white; a large patch of white under the chin, wide above and narrowing to a rounded point on middle of lower breast. White is thus everywhere *symmetrically* distributed on the two sides of the body. The birds from late in the season of 1908 all had much white!"

² Only the date of hatching is known for these eggs.—EDITOR.

³ This bird used as sire in the mating fully described in the text, p. 95.—EDITOR.

TABLE 71.

♂ *C. tabellaria* (Hom. 1); from fancier (2+ yrs.) 1897; killed (cats) 1902; fairly thickly chequered.
♀ *C. tabellaria* (Hom. 3); stray 1898; lost 1902; thickly chequered.

♀ A 1. 4/11/99; hatched }
♀ A 2. 4/13/99; hatched } both chequered, but one more than the other.

♂ B 1. 5/27; hatched, lighter than either parent; frills.
B 2. 5/29; no development.

C 1. 6/27; hatched, color? E 1. 8/24; did not hatch.
C 2. 6/29; hatched, color? E 2. 8/26; hatched; color?

♂ D 1. 7/26; black as sire. F 1. 9/20 } one lost on trip.
♀ D 2. 7/28; blacker than sire. F 2. 9/22 } one no development.

G 1. 10/16; hatched, black chequers a little blacker than sire; less than D 2.
G 2. 10/18; hatched, black chequers a little blacker than sire; less than D 2.

H 1. 11/19; hatched, a little blacker than sire.
H 2. 11/21; hatched, a little blacker than sire.

♂ I 1. 1/22/00; hatched chequered less than sire. J 1. 3/7; did not hatch.
♀ I 2. 1/24/00; hatched chequered less than sire. ♀ J 2. 3/9; hatched, strongly chequered with black.

♂ K 1. 4/8; hatched darker than sire.
♀ K 2. 4/10; hatched darker than K 1 = strongly and evenly chequered (see pl. 4, Vol. I).

♂ M 1. 6/12; hatched, pure gray with 2 black bars. L 1. 5/13; hatched (killed at once).
M 2. 6/14; hatched, more thickly chequered than sire. L 2. 5/15; some development.

N 1. 7/15; hatched, more black than sire, left hind toe white (r. = black).
N 2. 7/17; hatched, as black as sire, a short white streak behind eyes.

O 1. 8/20; hatched, no record of color.
O 2. 8/22; hatched, no record of color.

"These birds were left at Woods Hole during the winter of 1900-01 in charge of Mr. Bernt Olsson, who raised several young without chequers, having only gray color with two black bars."

P 1. 7/9/01 } no record kept during
P 2. 7/11/01 } summer 1901.

Q 1. 12/9 }
Q 2. 12/11 } one paler than the other.

A daughter; pale gray, no chequers (from early 1900); given (Hom. 1) 1/19/02.

A 1. 2/6/02; shell rather soft. B 1. 2/22 } one gray, no chequers; other chequered less
A 2. 2/8/02; shell not strong. B 2. 2/24 } than sire.

C 1. 4/3; hatched, killed. D 1. 7/1; no record. E 1. 9/29; hatched.
C 2. 4/5; hatched, killed. D 2. 7/3; no record. E 2. 10/1; hatched.

(BB 5)

(BB 5)

TABLE 72.

♂ C. tabellaria (K 1); brother; 4/8/00; strong black chequers.

♀ C. tabellaria (J 2); sister; 3/9/00; strong black chequers (a white fleck over eye).

♀ A 1. 10/26/00; hatched, less black than parents, touch of white behind each eye (dark streak in right iris).

♂ A 2. 10/28/00; hatched, less black than parents, touch of white behind each eye (dark streak in left iris.)

♂ B 1. 12/28; hatched, dark chequered (nearly) as parents; traces white, asymmetrical upper mandible.

♂ B 2. 12/30; hatched, dark chequered as parents; traces white and red.

C 1. 2/20/01; broken.

D 1. 3/10/01; hatched; no record.

E 1. 4/8; hatched; no record.

C 2. 2/22/01; broken.

D 2. 3/12/01; hatched; no record.

E 2. 4/10; hatched; no record.

F. 1/13/02; hatched (very light complexion), dead at 5 days.

G 1. 2/18; hatched; reddish-black chequers.

G 2. 2/20; hatched; color of dam almost perfect even to the white spot over eye.

H 1. 4/2 } one is like the dam; other is dark chequered, variegated with much white.

H 2. 4/4 }

I 1. 5/12; hatched; killed (presumably because neither very dark, nor peculiar).

I 2. 5/14; hatched; killed (presumably because neither very dark, nor peculiar).

J 1. 6/28; no record.

K 1. 2/1/03 } one hatched "dark as parents"; other prob-

J 2. 6/30; no record.

K 2. 2/3/03 } ably not hatched.

L 1. 3/9/03; removed.

M. 4/15; dark chequered as parents.

L 2. 3/11/03; removed.

N. 5/17; deserted.

♀ { O 1. 6/4 } one dark chequered as parents, and killed; other a ♀ (5) blackish-red chequered; freckled with white behind both eyes.

♀ { O 2. 6/6 }

♂ { P 1. 9/8 } one a ♂ (6) black red chequered; mated 1904

Q 1. 4/13/04 } one has dull red chequers; other is normal

♂ { P 2. 9/10 } with No. 5 above.

Q 2. 4/15/04 } color of female parent.

R. 1/24/05; hatched; soon died.

S 1. 3/23 } both very light complexion; one died, other (8) has more strongly red chequers than any before it; also has

S 2. 3/25 } white flecks on the head.

(BB 6)

(BB 6)

TABLE 73.

♂ Homer (C 1); hatched 3 5/01; even gray; 2-barred ("double-nephew" to the mate).

♀ Homer (C) = (3); 3/15/01; 3d bar very obscure; chequers none on wing, few on scaps.

A 1. 3/14/02; probably not hatched.

A 2. 3/16/02; probably not hatched.

B 1. 4/11 } both hatched, one was 2-barred and dark gray, other, very light or pale gray with two reddish bars.¹
B 2. 4/13 }

C. ?; hatched, pale with reddish bars.

D 1. 10/1; no record.

F 1. 3/26; no record.

H. 9/13; no record.

D 2. 10/3; no record.

F 2. 3/28; no record.

E 1. 2/14/03; hatched; no record.

G 1. 7/4; no record.

I. 5/15/04; no record.

E 2. 2/16/03; failed.

G 2. 7/6; no record.

(BB 9)

¹ "The imprints of some chequers for a third bar were present as a tinge of reddish."

TABLE 74.

♂ C. tabellaria (6); brother; 9/8/03; 8/3/06; black-red chequers.

♀ C. tabellaria (5); sister; 6/5/03; blackish red chequers.

A 1. 4 12/04; removed.

D 1. ? no development.

G 1. ? no development.

A 2. 4/14/04; removed.

D 2. ? no development.

G 2. ? no development.

B 1. 5/15; no development.

E 1. ? no development.

H 1. ? no development.

B 2. 5/17; no development.

E 2. ? no development.

H 2. ? no development.

C 1. 7/6; probably no development.

F 1. ? no development.

I 1. ? no development.

C 2. 7/8; probably no development.

F 2. ? no development.

I 2. ? no development.

D 1. 1/25/05 } one hatched; dead (care) few days; other

E 1. 3/5; a little development.

D 2. 1/27/05 } egg failed.

E 2. 3/7; a little development.

F 1. 4/4; not tested.

H 1. 5/30; no development.

F 2. 4/6; not tested.

H 2. 6/1; no development.

G 1. 5/1; no development.

I 1. 7/24 } few days development, in one, or both.

G 2. 5/3; no development.

I 2. 7/26 }

J. 1/7/06; bird hatched, but "suspected another male had fertilized this egg."

K 1. no development.

K 2. no development.

(BB 7)

TABLE 75.

♂ C. tabellaria (1907); 3-barred, trace chequers on scapulars, same as sire.

♀ C. tabellaria (from fancier 1907); 2-barred, true rock type; dead 5/7/09.

♀ { A 1. 12/10/07 } hatched; one killed;¹ other a pale ♀ 3 bars; weak chequers.
A 2. 12/12/07 }

B 1. 5/12/08; hatched; color like sire.

B 2. 5/14/08; hatched; color like dam.

C 1. 6/15/08; hatched } about color of old birds, killed.
C 2. 6/17/08; hatched }

D 1. 9/5; hatched; "not peculiar"; killed

D 2. 9/7; hatched; "not peculiar"; killed

♀ E 1. 10/28; light gray; 2 narrow bars, a trace of third; obscure chequers on scap's.; frills (see pl. 71, Vol. I).

♀ E 2. 10/30; trace darker than E 1; 2 bars, no trace of third; no chequers.

♀ F. 2/2/09; hatched; very light gray; 2 extremely narrow bars.

♂ G 1. 3/23; hatched; rock-gray; 2 bars, narrowed.

♀ G 2. 3/25; hatched; rock-gray; 2 bars, about normal.²Above ♀ disappeared, and ♀ F (2/2/09 above) mated to sire;³ very narrow bars.

♂ H 1. 8/10/09; hatched; very light; 2 bars with most black washed out; breast frill.

♀ H 2. 8/12/09; hatched; clear rock-gray; 2 narrow bars.

♂ I 1. 11/15; hatched; rock-gray; only 4 spots of posterior bar, anterior bar absent (see pl. 16), except few "freckles"; frilled

♀ I 2. 11/17; hatched; almost white⁴ or silver gray; 2 weak bars (see pl. 16); frilled.

J 1. 1/7/10; no development.

J 2. 1/9/10; no development.

♂ K. 2/5; hatched; dark gray tinged with brown; bars weak.

♂ L 1. 2/13; very dark gray like K; bars obscure.

♀ L 2. 2/15; color light; narrow bars, these disappearing in lower half.

(G 12)

¹ The original purpose of this breeding was to get progeny of "two bars" or less (without chequers). The birds that gave little promise of leading in this direction were usually killed as soon as they came to full plumage.—EDITOR.² "Thus from E to G we have had only 2-barred young, with bars sometimes much below the normal width and density." (G 12)³ "This female was barely 5 months old and mated at once. From this *inbreeding* I hope to see the bars further reduced."⁴ It is notable that this female was fertile—at least 1 egg of 2 laid—when mated with her clutch-mate brother (I 1); there is no record of this offspring after hatching and it probably died before old enough to disclose its color. It seems probable, too, that this single clutch was all that was produced in 1910.—EDITOR.

TABLE 76.

♂ *C. tabellaria* (H 4) (stray, 1900); 2 bars + trace of third bar, and chequers (see pl. 4, Vol. I).♀ *C. tabellaria* (K 2); 4/10/00; 3 bars + chequers; quite dark gray (see pl. 4, Vol. I).

♂ and ♀	A 1. 11/28/00; no development.	
	A 2. 11/30/00; no development.	
♂ and ♀	B 1. 1/25/01 } one, a ♀ pale gray, 3 bars, a fourth of only 3 spots (<i>intermediate</i>); slightly darker than sire; other	
	B 2. 1/27/01 } a ♂ medium dark gray; darker than dam (i.e., darker parent).	
♀	C 1. 3/12 } one a ♀ (3) dark gray like dam but fewer chequers (<i>intermediate</i>); other 3 bars but no chequers,	
	C 2. 3/14 } nearer sire (<i>intermediate</i>).	
	D 1. 4/17; hatched, no record.	
	D 2. 4/19; hatched, no record.	
	E 1. 5/25 } both young about midway between parents (<i>intermediate</i>);	
	E 2. 5/27 } but one perceptibly paler than the other (<i>intermediate</i>).	
	F 1. 7/20; no record.	G 1. 1/18/02; broken.
	F 2. 7/22; no record.	G 2. 1/20/02; broken.
	H 1. 2/12/02; more chequered than sire, less than dam (<i>intermediate</i>).	
	H 2. 2/14/02; more chequered than sire, less than dam (<i>intermediate</i>).	
	I 1. 4/1; hatched; apparently not notable; killed.	
	I 2. 4/3; hatched; apparently not notable; killed.	
	J 1. 7/1; no record.	K 1. 8/4 (?); hatched; medium chequered (<i>intermediate</i>).
	J 2. 7/3; no record.	K 2. 8/6 (?); hatched; medium chequered (<i>intermediate</i>).
	L 1. 10/29; hatched; plain gray with 2 narrow bars }	one dead 2/14/03; other dead 3/13/03.
	L 2. 10/31; hatched; plain gray with 2 narrow bars }	
	M 1. 12/?; failed to hatch.	
	M 2. 12/?; failed to hatch.	
	N 1. 2/12/03 }	one has chequers same as female parent, other has no chequers, and only 2 narrow bars.
	N 2. 2/14/03 }	
	O 1. 3/30; chequered about as strongly as dam.	
	O 2. 4/1; plain light gray; chequers reduced.	
	P 1. 5/6 }	Q 1. 7/6; no record.
	P 2. 5/8 }	
		Q 2. 7/8; no record.
		R 1. 9/12; no record.
♂	S 1. 4/14/04 (7); chequered more than sire (<i>intermediate</i>) (see pl. 5, Vol. I).	
♀	S 2. 4/16/04 (8); pale; bars pale, and third bar weak ¹ (see pl. 5, Vol. I).	
	T 1. 5/11.	U 1. 5/26; not tested.
	T 2. 5/13.	U 2. 5/28; not tested.
	W 1. 1/6/05; hatched; no record.	X 1. 3/3; color <i>intermediate</i> .
	W 2. 1/8/05; hatched; no record.	X 2. 3/5; color very pale (bars not described).
	Y 1. 4/15 } complexion very light (apparently died early) in one; other, if hatched, died early and thrown from	
	Y 2. 4/17 } nest by parents.	
	Z. 5/25; no record.	

¹ It is noted that the two birds of this clutch were mated Dec. 1904, but I have been unable to find the data.—EDITOR.² It is noted at this point that "so far 5 young with only 2 bars and pale gray; nearly all the rest are less chequered than the dam."

TABLE 77.

♂ Black barb; from dealer; 2/1/01.

♀ Black barb; from dealer; 2/1/01 dead; winter 1901-02

A 1. 2/11/01; broken.	D 1. 5/24; (black if hatched).
A 2. 2/13/01; developed, but broken.	D 2. 5/26; (black if hatched).
B 1. 3/5; no development.	E 1. 7/13; hatched; black.
B 2. 3/7; no development.	E 2. 7/15; hatched; black.
C 1. 4/15; hatched; black.	
C 2. 4/17; hatched; black.	
Daughter of above ♂ given (=black of 1901). This <i>inbreeding</i> gave:	
A. 2/7/02; no development.	C 1. 4/9; probably did not hatch.
B 1. 3/3; hatched; dead 7 to 10 days.	C 2. 4/11; probably did not hatch.
B 2. 3/5; hatched; dead 7 to 10 days.	
D 1. 2/11/03; black }	♀ { G 1. 7/5 } one red ♀, other black (soon died).
D 2. 2/13/03; black }	
E 1. 3/24 } one black, other gray.	♂ and ? { H 1. 9/12; red } one died 2 to 5 mo.; other (♂);
E 2. 3/26 }	
♂ F 1. 5/9; red. (1)	
F 2. 5/11; not hatched.	

TABLE 77 (*continued*).

I 1. 4/20/04; black.	K 1. 7/?	} one red; other (? unhatched).
I 2. 4/22/04; black.	K 2. 7/?	
J 1. ? — ?	L 1. 9/?	} one red, dead at 2 weeks; other (? unhatched).
J 2. ? — ?	L 2. 9/?	
(? Other eggs probably laid; not recorded.)		
<hr/>		
J 1. 1/1/05	} one black, died early; other red, died 1 mo.	
J 2. 1/3/05		
♂ { K 1. 2/12	} one red ♂, alive 1909; other not hatched.	
{ K 2. 2/14		
L 1. 3/24	} one black, dead (lice) at 2 weeks; other un-	
L 2. 3/26		
hatched.		
This ♀ became tubercular, produced no eggs in 1906; was killed.		
<hr/>		
M. 4/28; no record.		
N 1, N 2, probably not recorded.		
O 1. 8/13; black.		
O 2. 8/15; red (killed by lice).		

There is no record of barbs produced in 1907. In 1908 this male was mated to another daughter—black—(of 1905?). A few eggs probably laid, without record until May.

♀ A 1. 5/13/08; gray;¹ dead 12/19/08.

♀ A 2. 5/15/08; gray; dead (?) 4/24/12 (mated w. brother 1909).

(BB 3)

¹ At this point in the breeding of these black barbs it is remarked that "this is an interesting case, as the color runs from black to red and to gray; black being most frequent, red occasional, and gray very rare." Black color predominates, and most pronouncedly so at the season of strongest germs (spring) and in the kind of matings (unrelated, or mature parentage) elsewhere found to be productive of strong progeny.—EDITOR.

TABLE 78.—*Brother-sister matings of black barbs.*

♂ Black barb; (1903–1905); brother; black color.

♀ Black barb; (1903–1905); sister; black color.

Early 1908, probably one or more clutches before:

? 7/17/08 } one black, other gray; both dead autumn 1908.
? 7/19/08 }

A 1. 2/27/09; hatched; black.

B 1. 4/18; no record.

A 2. 3/1/09; hatched; black.

B 2. 4/20; no record.

♂ Black barb; brother or half-brother to mate (A 2).

♀ Black barb; of gray color; (A 2); 5/15/08.

A 1. 3/28/09; hatched; black; dead (care ?), tuberculosis, after 15 days.

A 2. 3/30/09; did not hatch.

B 1. 4/27; probably no development.

B 2. 4/29; probably no development.

♂ Red barb (K, alive 1909) mated to ♀ red and white Jacobin produced:

♀ { A 1. 2/18/06 } one hatched; blackish, with little red; other no data.
 { A 2. 2/20/06 }

B 1. 3/19; hatched; dusky brown.

C 1. 5/16; blackish and chequered.

B 2. 3/21; hatched; pale red.

C 2. 5/18; hatched, red.

(BB 3)

TABLE 79.

Pair A.

♂ Gray Brünn pouter; from fancier; 2/17/08; gray with white bars edged w. black.

♀ Gray Brünn pouter; from fancier; 2/17/08; gray with white bars edged w. black.

♀ A 1. 4/12/08 1 gray; juvenal bars black, adult red with black borders.

A 2. 4/14/08; dead at 2 weeks.

♂ B 1. 5/16.....2.....gray impure with black; juvenal bars purer white than in parents.

♀ B 2. 5/18.....3.....gray; with white bars.

Pair B.

♂ Parent died 6/4. A second male, like first in color, given about 6/15/08.

♂ A 1. 6/28/08.....4.....color of parents; alive 10/14/09 (see pl. 18).

A 2. 6/30/08.....5.....nearly naked at hatching; very small; dead 7/23/08.

♀ B 1. 8/1.....6.....color of parents, alive 10/14/09 (see pl. 18).

♂ B 2. 8/3.....7.....color dark gray with red bars¹ (see pl. 14).

♀ C 1. 9/22.....8.....dark gray; juvenal bars red-black, but in adult turned to white with black border (see pl. 14, *ad.*; pl. 17, *juvenal*) dead 9/1/09.

♀ C 2. 9/24.....9.....white;² long unable to fly, dead 1/27/09, good care (see pl. 17).

D 1. 11/5.....10.....color of parents.

D 2. 11/7.....11.....6 right outer flights "white"; 5 left outer flights "white"; dead 12/28/08 (care).

E 1. and E 2; 12/18 to 20; deserted.

F 1. 1/26/09; hatched; no later record.

F 2. 1/28/09; failed.

TABLE 79 (continued).

Pair C.

♂ Parent died 2/7/09. One (not recorded which) of the sons from 1908 then put here with dam; his color was normal (see pl. 18).

G 1. 3/31/09; no record.

H 1. No record.

I 1. No record.

G 2. 4/2/09; no record.

H 2. No record.

I 2. No record.

J. 7/18. hatched. 11. color gray rock, 2 black bars (see pl. 18).

K. 11/8. hatched. 12. adult color like parents pale gray, white bars.

(G 15, G 16)

¹ "The 'red' in the juvenal feathers is about the same as the red in the adult feathers of No. 1 above; i.e., this bird is a step higher in evolution than No. 1 was. The adult bars in No. 7 are red with black borders."

² "The juvenal white pouter (9) came at the end of the season (see record) and the dark gray pouters with red bars (black-edged) came later in season, and so far (Mar. 29) these birds, although mated, and making nests and sitting, have produced no eggs." (R 16)

TABLE 80.—Gray Brünn pouters in brother-sister matings.

Pair 1.

♂ 2; two white bars edged with black, body gray, "sprinkled with black."

♀ 3; two white bars edged with black, body gray without black.

"Previous to July 1909 this pair raised 3 young; 2 were like the parents and a third resembles the others, but was hatched about June 25, and is weak in some respects. Among other things, the legs diverge a little more than they should, and the 'fundamental barring' is apparent through failure of the normal production of pigment. The fundamental bars have here wrought conspicuous effects upon the tail, flights, tail coverts, secondaries, and other parts." This bird seems to have been the last bird produced in 1909. The record for 1910 is also complete with the following pair of eggs.—EDITOR.

♀ C 1. 3/14/10; hatched; juvenal light gray, 2 white bars (and fundamental bars).
C 2. 3/16/10; hatched; juvenal color dark gray, 2 black bars, with trace of red.

Pair 2.

♂ 4; gray², with white bars edged with black.

♀ 6; gray, with white bars edged with black.

A 1. 2/3/09; no test.

B 1. 3/10; killed.

C 1. 4/15; no record.

D 1. no record.

A 2. 2/5/09; no test.

B 2. 3/12; killed.

C 2. 4/17; no record.

D 2. no record.

E 1. 8/9; hatched; rock gray, with black bars (see pl. 18).

E 2. 8/11; hatched; color red throughout (see pl. 18).

Pair 3.

♂ 7; dark gray; bars red with black borders.

♀ 8; dark gray; bars white with black borders.

A 1. 7/09; failed to hatch.

A 2. 7/09; failed to hatch.

B 1. 4/1; hatched; no record.

B 2. 4/3; hatched; no record.

♀ C 1. 5/10; hatched; color of parents, dead 9/1/09 (see pl. 17).

♂ C 2. 5/12; only white and brown orange; legs diverge; dead 2/12/10 (see pl. 17); frills.

D 1. 7/6; no record.

D 2. 7/8; no record.

♂ E 1. 8/21; hatched; color rock gray, with red-orange bars.

E 2. 8/23; hatched; color red-orange throughout, basal parts of feathers white, no bars (see pl. 14).

(G 16, G 15)

¹ For the explanation of this barring see Chap. VIII, Vol. I, of these works and Riddle, Biol. Bull. 1908.—EDITOR.

² "This male is not pure rock-gray; there are touches of blackish on the wing coverts."

TABLE 81.

♂ Black Brünn pouter; with 2 white bars (from fancier).

♀ Black Brünn pouter; with 2 white bars (from fancier).

A 1. 3/29/08. 1. no record of color or death.

B 1. 6/4. 3. no record of color.

♂ A 2. 3/31/08. 2. color of parents.

B 2. 6/6. 4. no record of color

♀ C 1. 8/17. 5. gray with 2 bars black; alive 4/10/09.¹

C 2. 8/19. gray with 2 bars black; died before 4/10/09.

A 1. 4/12/09. 6. "guinea marks"; white bars partially replaced by red and black.²

♀ A 2. 4/14/09. 7. anterior bar black,³ posterior bar partially replaced by red and black.

? 1. 7/13. 8. "guinea marks"; 2 bars different.

♀ ? 2. 7/15. 9. anterior bar, black,³ posterior bar mostly black.

(G 16)

¹ "A pair of young hatched in September 1908 were both gray with two bars black. One of these died, sex not noted. The other now alive (4/10/09) is a female (!) and mated with a black barb of 1909." In view of this statement it seems probable that the colors of Nos. 1, 3, and 4 were, in most cases at least, normal.—EDITOR.

² No. 6 died at 4½ months; No. 7 at 10 weeks (white).

³ Black bars in the black offspring means that the bars scarcely exist as differentiations in the coloration of the wing.—EDITOR.

TABLE 82.

Pair 1.

♂ Owl (1-C 2); hatched 5/4/00, with a frill.

♀ Rock (RK 1); pale gray; small, no frill.

♀ A 1.	10/15/00.	disappeared 3/3/01.	color owl-like; no frill.
♂ A 2.	10/17/00.		color dark rock; no chequers.
♀ B 1.	11/26.	dead 3/24/02 (16 mo.)	color owl-like; no chequers, no frills.
♂ B 2.	11/28.	killed 3/?/02.	color dark rock; no chequers. ¹
C 1.	1/28/01;	failed to hatch.	
♀ C 2.	1/30/01.		color pale, owl-like; no frills, no chequers.
D 1.	3/11;	accident.	
♂ D 2.	3/13.	dead 3/19/02 (12½ mo.)	color dark rock.
E 1.	4/17.		color dark rock.
E 2.	4/19.		color gray rock.
G 1.	7/9.		color owl-like.
♂ G 2.	7/11.	4/12/02 (9 mo.)	color dark rock.
H 1.	8/10.		color dark rock; no frills. ²
H 2.	8/12.		color dark rock; no frills.

(G 17)

¹ The two birds from this clutch mated, 1901-2; see table 84.² The owl (*C. turbata*) has a tuft or frill at the breast (see text-figs. 28, 29, Vol. I).

TABLE 83.

Pair 2.

♂ Owl; age unknown.

♀ Rock (RK 2); large; gray color.

♀ A 1.	1/19/01.	dead 5/10/02 (confinement ?)	color owl-like; very light gray.
♂ A 2.	1/21/01.	dead 12/29/01.	color dark gray; no chequers.
♂ B 1.	3/8.	dead 4/20/02.	color dark gray.
B 2.	3/10.	crushed hatching.	color owl-like.
♀ C 1.	4/17.	4/2/02.	color owl-like.
C 2.	4/19.		color owl-like.
♀ {D 1.	5/27}	♀ dead 4/22/02; 1 owl-like; 1 dark color.	
D 2.	5/29}		
E 1.	7/14.		color pale owl-like.
E 2.	7/16.		color dark gray.

(G 17)

TABLE 83A.

Pair 3.

♂ Owl I-CI; hatched 5/4/00.

♀ Rock-RK 3; black chequered; thickly chequered.

♂ and ♀ A 1. 10/31/00 } one is a ♀ owl-like (light gray) but with an even brown chequering, instead of black chequering;
A 2. 11/2/00 } alive 1/15/02. Other is a ♂; dead (cold) 12/22/00; dark rock, strongly chequered.

♂ B 1. 12/23 dead 7/12/02 (cholera ?) color dark rock, strong chequers.

♂ B 2. 12/25 dead 7/12/02 (cholera ?) color dark rock, strong chequers.

♀ C 1. 1/19/01 color owl-like, pale chequers.

C 2. 1/21/01 color rock-like, dark chequers.

D 1. 3/3 color rock-like, dark chequered.

D 2. 3/5 color owl-like, pale chequers.

E 1. 4/6; some development.

E 2. 4/7 color dark rock, dark chequers.

♂ G 1. 7/22 dead 7/12/02 (cholera) color dark rock, dark chequers.

G 2. 7/24 color owl-like, pale chequers.

I 1. 3/23 } one hatched, owl-like; pale chequers; other, no record.

I 2. 3/25 }

K 1. 7/2 color owl-like, pale chequers.

K 2. 7/4 color owl-like, pale chequers.

L 1. 8/6 color dark chequers.

L 2. 8/8 color dark chequers.

M 1. 9/27 } one of dark color and one of light color.

M 2. 9/29 }

(G 17)

(G 17)

TABLE 84.—*Inbreeding of owl-rock hybrids.**Pair 1 (brother and sister).*

♂ Owl-rock hyb. (B 2); (11/28/00); 3/24/02; dark gray; no chequers.

♀ Owl-rock hyb. (B 1); (11/26/00); 3/?/02 (killed); owl-like; no chequers.

A 1.	5/2/01.....	hatched, no record for color.
A 2.	5/4/01.....	probably hatched.
B.	6/1.....	hatched.....pale, owl-like.
♂ C 1.	7/14.....	hatched.....dead 1/20/02; dark gray rock.
C 2.	7/16.....	hatched.....killed 12/?/02; pale reddish.
D 1.	2/6/02.....	hatched.....red.
D 2.	2/8/02.....	hatched.....red.

Pair 2 (half-brother and half-sister).

A second female hybrid from owl (1-C 2) × rock (RK 3) black chequered given 5/10/02. This female (A 1) from egg 11/1/00 (alive 1/15/02) was of pale gray color, but with pale to brownish chequers. Six birds from this female and the above male gave no red offspring.

A 1.	4/19/01.....	hatched.....dead at 7 days, "whole appearance owl-like."
♀ A 2.	4/21/01.....	hatched.....matured and mated, "like sire in color and size."
B 1.	5/23.....	hatched.....dark gray, 2 black bars.
B 2.	5/25.....	hatched.....light gray, 2 bars owl-like.
C 1.	7/8.....	hatched.....pale owl-like.
♀ C 2.	7/10.....	hatched.....dead 4/8/02; pale owl-like. (G 2)

TABLE 85.

♂ *C. oenas*; 3/16/09.♀ *C. livia domestica*; 2-barred, rather dark gray.

A 1.	5/5/08.....	S-R 1.....	dead 7/13/08.
A 2.	5/7/08;	no development.	
♀ B 1.	5/28.....	S-R 2.....	dead 6/20/08 (feeding ?).
♂ B 2.	5/30.....	S-R 3.....	dead 6/21/08 (feeding ?).
♂ C 1.	6/27.....	S-R 4.....	dead at 7 days (feeding).
C 2.	6/29;	no development.	
♂ D.	7/11.....	S-R 5.....	dead 7/2/09 (fertile with <i>domestica</i>).
E 1.	7/31.....	S-R 6.....	dead 8/24/08 (overfeeding).
♀ E 2.	8/2.....	S-R 7.....	dead 8/23/08 (overfeeding). ¹
F 1.	9/2;	no development.	
F 2.	9/4;	no development.	
G 1.	9/13;	no development.	
G 2.	9/15;	no development.	

H 1. 2/14/09.....hatched; dead at 6 days (care ?).

H 2. 2/16/09.....hatched; dead at 6 days (care ?).

(P 6)

¹ "I noticed on August 22 that seed (millet) passed through the young undigested; the trouble is 'too much food.' It is necessary not only to use fine seed, but also to be very careful not to overfeed during the first week or two weeks. One must keep constant watch of the droppings and cut off the seed if it passes undigested. Some soft food (bread-crumbs), cuttle-fish bone, oyster-shell, charcoal, plenty of sand-grit, and some lettuce seem advisable or necessary."

TABLE 86.

♂ *Oenas* × *livia domestica* (S-R 5); 7/11/08; 7/2/09.♀ *C. livia domestica*; (from dealer 1909).

A 1.	3/21/09.....	SR-R 1.....	dead 4/23/09. ¹	B 1.	4/24.....	SR-R 3.....	dead 5/23/09.
A 2.	3/23/09.....	SR-R 2.....	dead 4/20/09.	B 2.	4/26.....	SR-R 4.....	dead 5/25/09.
C 1.	5/29.....	SR-R 5.....	dead 6/25/09; some unknown cause.				
C 2.	5/31.....	SR-R 6.....	dead 6/25/09; digestive trouble.				

♂ parent (S-R 5) died 7/2/09.

D 1. 7/4.....SR-R 7.....probably died autumn 1909; certainly before 12/30/10.

D 2. 7/6.....SR-R 8.....dead 7/31/09.²

(P 6, P 7)

¹ Neglect was cause of death.² "Color here seems to be that of the earlier hatched young." (P 7)

TABLE 87.

♂ *C. admista* (Z); 1894 or 1895; escaped 12/22/00.♀ *C. palumbus* (Cp); 10/5/02.

A 1. 6/26/99; no development.	E 1. 11/2; probably no development.	I 1. 6/7; no development.
A 2. 6/28/99; no development.	E 2. 11/4; probably no development.	I 2. 6/9; hatched; dead at 4 days.
B 1. 7/3; not hatched.	F. 1/28/00; broken. ¹	J 1. 7/12; no development.
B 2. 7/5; not hatched.		J 2. 7/14; some development.
C 1. 7/23 } one egg, some development.	G 1. 3/30/00; no development.	K 1. 8/1; probably no development.
C 2. 7/25 }	G 2. 4/1/00; no development.	K 2. 8/3; probably no development.
D 1. 8/10; no development.	H. 4/27; no development.	L 1. 8/30; probably no development. ²
D 2. 8/12; no development.		L 2. 9/1; probably no development.

(F 29)

¹ Laying at this season and to the extent here noted "is an interesting proof of the effect of domestication on the productivity of the wood-pigeon." (F 29)

² Later the female of the above record was mated to another common pigeon (*admista*?). A single young was hatched (6/3/02). It seems to have lived only 7 days. (A 14, A 1/7)

TABLE 87A.—Wild *C. livia* × *C. livia domestica*.♂ *C. livia*; from Inishbofin.♀ *C. livia domestica*; from fancier 1907; typical 2-barred in appearance.

A 1. 4/18/08; hatched.	B 1. 6/9 *; 20.	C 1. 7/15 *; hatched; 22.
A 2. 4/20/08; hatched.	B 2. 6/9 *; 21.	C 2. 7/15 *; hatched; 23.

♀ *C. livia domestica* (from fancier 12/27/08); 2-barred; trace of brownish in light blue gray. This ♀ has 13 tail feathers.

A 1. 1/20; failed (poor incubation).	C 1. 3/23; I-Kr 3.
A 2. 1/22; failed (poor incubation).	C 2. 3/25; probably did not hatch.
♂ B 1. 3/1 *; I-Kr 1; 3d vestigial bar; dead 4/28/08.	
B 2. 3/2 *; I-Kr 2; trace darker or browner than B 1.	(XS 2)

* Indicates date of hatching.

TABLE 87B.

♂ *C. livia* (2); from Inishbofin, 1901; dead 10/15/02.♀ *C. livia* (2); from Inishbofin, 1901; accident 1/13/04.

A 1. 3/8/02. 5.	♂ B 1. 4/23. 6.
A 2. 3/10/02. 5. dead 9/18/02.	♀ B 2. 4/25. 6. dead 10/9/02.

♂ *C. affinis* (3); from Inishbofin, 1901.♀ *C. livia* (3); from Dover, England, 1898.

A 1. 1/7/02 } one died at 1 week, other 2/26/02.	C 1. 3/1 } one 3 C; other dead at 1 week.
A 2. 1/9/02 }	C 2. 3/3 }
B 1. 2/14; broken.	♀ D. 4/15; 3 D; 2-barred; bars pale; ¹ dead 7/10/02.
B 2. 2/16. 3 B. typical 2-barred.	E. 5/29; no record.

♂ *C. livia* (number not certain).♀ *C. livia* (number not certain).

A 1. 12/14/02; failed (care).	D 1. 3/1. 7. dead 8/17/03.
A 2. 12/16/02; failed (care).	♂ D 2. 3/3. 7. alive 1905.
B 1. 1/14/03; broken.	♀ E 1. 4/23. 8. dead 3/10/05.
B 2. 1/16/03; broken.	E 2. 4/25. 8. accident 5/13/03.
C 1. 2/3; no record.	F 1. 7/8 } hatched.
C 2. 2/5; no record.	F 2. 7/10 } hatched.

♂ *C. livia* (0); from Inishbofin, 1901; dead 11/29/05.♀ *C. livia*; (earlier mated with owl).

♂ A 1. 3/19/05. R 10. dead 7/29/06.	D 1. 7/6. R 14.
♂ A 2. 3/21/05. R 11. dead 7/25/06.	D 2. 7/8; broken.
B 1. 4/25. R 12. escaped at few weeks.	♂ E 1. 7/23/05. R 15. dead 7/15/06.
B 2. 4/27. R 13. escaped at few weeks.	♀ E 2. 7/25/05. dead 10/2/05.
C 1. 6/1. hatched; killed at 3 weeks.	♂ F 1. 9/15/05. R 16. dead 7/16/06.
C 2. 6/3. hatched; killed at 3 weeks.	F 2. 9/17; no record.

(XS 2)

¹ According to a statement in the text, "pale bars" were apparently the rule in these hybrids.—EDITOR

TABLE 87c.

♂ *C. affinis* (3); from Cromarty Caves, Scotland, 1908.♀ *C. affinis* (2); from Cromarty Caves, Scotland, 1908; dead 5/3/10.

♀ and ?	A 1. 3/10/09 *	CC 1.....	moderately chequered.....	alive 2/7/11.	
	A 2. 3/10/09 *	CC 2 ♀	fully chequered.....	dead 6/30/13.	
♂ B 1.	3/27.....	CC 3.....	typical 2-barred rock !.....	dead 12/3/12.	C 1. 6/2; poor incubation.
♂ B 2.	3/29.....	CC 4.....	typical 2-barred rock !.....	alive 2/7/11.	C 2. 6/4; poor incubation.
D 1.	6/20.....	CC 7.....	chequered nearly as parents.....	dead 10/2/09.	
D 2.	6/22.....	CC 8.....	chequered nearly as parents.....	dead 12/6/09.	
♀ E 1.	9/1 *	CC 9.....	chequered nearly as parents.....	dead 12/16/09.	
E 2.	9/2 *	CC 10.....	typical 2-barred rock !.....	dead 1/12/10.	

♂ *C. affinis* (1).♀ *C. livia* (3); killed 5/3/10.

♂ A 1.	{ 3/12/09 *.....	CCB 1.....	fully chequered; very small testes; dead 6/21/13.
♂ A 2.	{ 3/12/09 *.....	CCB 2.....	typical 2-barred..... dead 5/12/11.
♂ B 1.	4/5.....	CCB 3.....	typical 2-barred..... alive 2/7/11.
♂ B 2.	4/7.....	CCB 4.....	chequered..... dead before 2/7/11.
♂ C 1.	5/10.....	CCB 5.....	typical 2-barred..... dead 5/3/10.
♀ C 2.	5/12.....	CCB 6.....	typical 2-barred..... dead 1/28/11.
D 1.	7/25 *.....	CCB 11.....	typical 2-barred..... alive 1912.
♀ D 2.	7/25 *.....	CCB 12.....	typical 2-barred..... dead before 2/7/11.

♂ *C. livia* (1); from Cromarty Caves, Scotland, 1908.♀ *C. livia* (2); from Cromarty Caves, Scotland, 1908.

♂ and ♀	A 1.	{ 3/31/09 *.....	C-B 1 ♂.....	typical 2-barred.....	dead 5/4/11.	
	A 2.	{ 3/31/09 *.....	C-B 2 ♀.....	darker gray, no white on rump..	dead 5/6/09.	
♀ B 1.	4/24.....	C-B 3.....	typical gray.....	dead 12/7/09.		
♀ B 2.	4/26.....	C-B 4.....	"darker gray"; bars not black, dusty blackish;	dead 8/15/09.		
C 1.	6/22 *.....	C-B 5.....	typical 2-barred.....	dead 5/12/11.		
♀ C 2.	6/23 *.....	C-B 6.....	"dark gray with weak bars".....	alive 1912.		
D 1.	7/23.....	C-B 7.....	typical 2-barred.....	alive 2/7/11.		
D 2.	7/25.....	C-B 8.....	"died young (5 days) but undoubtedly to be 2-barred."			
E 1.	4/10/10.....	C-B 9.....	typical 2-barred.....	alive 11/1/14.		
E 2.	4/12/10.....		hatched, neglected.			
♀ F.	6/7 *.....	C-B 10.....	typical 2-barred.....	dead 3/16/13.		
G 1.	8/26 *.....	C-B 11.....	"died before flying."	H 1. 11/19; probably not hatched.		
G 2.	8/27 *.....	C-B 12.....	"died before flying."	H 2. 11/21; probably not hatched.		(C, L)

* Indicates date of hatching.

TABLE 87d.

♂ *C. livia* (?) (CC 4); 3/29/09; alive 2/7/11; 2-barred from *chequered* parents.♀ *C. livia* (C-B 7); 7/23/09; alive 2/7/11; typical 2-barred.

♂ A. 7/15/10 *..... CC-4-A..... juvenal plumage = typical 2-barred; dead 9/25/10.

♂ *C. livia* (?) (CC 3); 3/27/09; 12/3/12; typical 2-barred from *chequered* parents.♀ *C. livia* (C-B 6); 6/23/09; alive 1912; dark gray with weak bars.

♂ A.	(date ?).....	2 C 1.....	dead 1/13/13.	
? ♀ B 1.	(date ?).....	2 C 2.....	2-barred.....	alive 9/10/12. C 1. 10/15/10... 2 C 4.
♀ B 2.	(date ?).....	2 C 3.....	dead 11/2/12.	C 2. 10/17/10... 2 C 5.

♂ *C. livia* (C-B 1); 3/31/09; dead 5/4/11.♀ *C. livia* (4); from Cromarty Caves, Scotland, 1908.

A 1.	8/1/10 *.....	CB 4 A.....	2-barred.....	dead 4/16/11.
A 2.	8/2/10 *.....	CB 4 A.....	2-barred; alive 2/7/11 (probably lost tag);	escaped 11/26/13.

♂ *C. affinis* × *livia* (CC-B 2); 3/12/09; 5/12/11; brother; typical 2-barred.♀ *C. affinis* × *livia* (CC-B 6); 5/12/09; 1/28/11; sister; typical 2-barred.

A. 9/?/10..... 2 C-B 2..... typical 2-barred. (E, LE)

* Indicates date of hatching.

TABLE 87D (continued).

♂ *C. livia* (R 11); 3/21/05; 7/25/06; son.♀ *C. livia* (earlier with *C. livia*, and *C. turbata*); mother.

A. 1/22/06.....	R 17.	B 1. 3/18*.....	R 18.
		B 2. 3/18*.....	dead at 1 week.
C 1. 5/3*.....	R 19.....	with few white primaries and 3d bar.	
C 2. 5/3*.....	R 20.....	pure in color and bars; lived less than 2 years.	
D 1. 5/19.....	R 21; no other record; lived less than 2 years.		
D. 2 5/21.....	R 22; no other record; lived less than 2 years.		

(XS 2)

♂ *C. affinis* × *livia* (CC-B 4); 4/7/09; dead before 2/7/11; chequered.♀ *C. affinis* × *livia* (?)¹ (CC-B 10); 7/31/09 to 11/28/11; weakly chequered.

♀ and ?	{ A 1. 5/23/10*.....	2 CC-B 1.....	dead 7/3/13.
	{ A 2. 5/23/10*.....	2 CC-B 2 ♀; bars and chequers as in dam at same age; ¹	dead 10/5/13.
	B 1. 7/5*.....	2 CC-B 3.....	weakly chequered; disappeared 8/24/10.
	B 2. 7/5*.....	2 CC-B 4.....	typical 2-barred.
	C 1. 7/11.....	2 CC-B 5.....	evenly chequered; disappeared before 2/7/11.
	C 2. 7/12.....	2 CC-B 6.....	evenly chequered; disappeared before 2/7/11.

(E, LE)

* Indicates date of hatching.

¹ The parentage of this bird is not above suspicion. She was probably a hybrid, *affinis* × *livia*. "This female (CC-B 10) in juvenal plumage had two very pale bars, as if partially washed out; also a third bar about equally dark. In the adult stage she is weakly chequered on the scapulars, and scantily so on the wings."

CHAPTER X.

ZENAUDURA AND ITS CROSSES WITH ZENAIDA AND HYBRIDS.

The results of crossing mourning-doves (*Zenaidura carolinensis*) with a species of the related genus *Zenaida* are here presented in a series of tabulated breeding records. The data for fertility, sex, and longevity, though not complete, are as nearly so as it has been possible to make them. The records for the breeding of pure mourning-doves and pure zenaidas are also given. Of chief interest, however, is the appearance of a "mutant" from *Zenaida vinaceo-rufa* and the behavior in inheritance of the new character in crosses with *Zenaidura* and its hybrids. The full consideration of this "mutation," together with a large group of illustrations, is given in Chapter IX of Volume I, where the nature and phylogenetic relations of the "new" character are treated (by the author) in connection with the broader subject of the direction of evolution of the color-pattern of pigeons in general. Much of the present textual statement and a tabulated summary have been supplied by the editor; the author's statements are here given the form of quotations.

The records for 6 pairs of mourning-doves¹ (tables 89 and 90) show that these birds breed in captivity with nearly full fertility. In reciprocal crosses with the closely related genus *Zenaida* they are about equally fertile (tables 91 and 93). This is a result parallel to that already found (Chapter VII) in crosses of two other genera which are not distantly related to each other, *Turtur* and *Streptopelia*. Even *inter se* matings of these hybrids (tables 94, 95, 97, 98) are almost fully fertile; when back-crossed to the parent species they are, with *Zenaida* at least (table 96), quite fertile. This maintenance of high fertility by the mourning-doves in their crosses with *Zenaida* is, however, in marked contrast with the very low fertility of mourning-doves when crossed with the much more distantly related forms (*Streptopelia*) to be described in Chapter XI.

The inbreeding of 3 pairs of hybrids supplies a group of offspring of shorter life-term than is elsewhere found in these records. The data are fully given in table 97.

A short consideration only will be given here to the "mutation" which arose in the breeding of *Zenaida vinaceo-rufa* Ridgway. A statement concerning its character and origin, and another touching upon its behavior and permanence in a long line of the breeding tests, must suffice.² The various tabulations present most of the data specially germane to the present volume.

In this "mutation" we have to do with (1) a "mutational" color-character—a white triangular mark at the tip of all of the feathers of several parts of the body; (2) the "mutational" character exists only in the juvenal plumage, the adult plumage of mutant and normal being alike; (3) the new character is clearly a strong modification of a region of the feather which is already differentiated slightly in the direction of the much-strengthened "new" character; (4) the mutational character exists as a specific character in *Columba guinea*, in some other pigeons,

¹ See plate 19.

² As noted above, most features of this mutation are fully treated in Chapter IX, in Volume I. Only the breeding data may appropriately be considered here.—EDITOR.



Adult male mourning-dove, *Zenaidura carolinensis*. $\times 0.8$. Hayashi del., Jan. 1909.

and in still other groups of birds; (5) the zenaidas possessed the character in an earlier stage of their phylogenetic history;³ (6) the "mutational" character persisted, and still persists, through several generations in crosses with *Zenaidura carolinensis* and its hybrids; (7) the character behaves in inheritance rather more as a "dominant" than as a "recessive," but there is some reason to believe that its behavior, as exhibited in the generic cross in which it has been perpetuated can not be accurately described in terms of "dominance."

The pedigree of the "mutant" (No. 21, see pl. 84, Vol. I) and of her mother (12, pl. 83, Vol. I) are given in table 92. The following statement concerning the "mutant" is taken from the record:

This bird was hatched September 28, 1906. The front and sides of the head, neck and breast, and abdomen, the wings and scapulars, and under tail-coverts, and even the tail-feathers (below), are all marked with this mid-terminal, triangular "white spot," which is the characteristic mark in the wing of the guinea-pigeon (pl. 81, Vol. I).

This bird is just a little larger than is No. 20 (which is of normal color, hatched August 18, 1906, from the same parents), but only a little younger. Both birds are now (November 9, 1906) in juvenal plumage and can be compared and photographed side by side. No one would take them for the same species, and yet they are from the same pure-bred parents.⁴ I expect that these marks will disappear in the adult plumage.⁵ If they do, then we have what might be called a juvenal-stage mutation. In other words, a character with all the appearance of a mutation, but transient.

It is important to know if this character is *entirely* new, or if it is a great enlargement of a minute feature of the normal juvenal feathers. The photograph of No. 20 shows just a beginning of this character on the neck—just a mere line. This terminal dividing-mark is not white in the normal form, but pale buff or pale brown. I have seen the same mark nearly and of similar color in some young Japanese and European turtle-doves, in young *Leptoptila*, and in the young of Florida ground-doves.

This character (white triangular mark) is a permanent character in the African guinea-pigeon. In this species we should have no doubt about calling it a character. The mutationist would hold that it is an *immutable unit*. Yet we see that it certainly is only an enlargement of the very minute dividing-line. Even in this specimen it is reduced to mere lines on the crown of the head and on the throat. What appears then to be a mutation turns out to be *not a really new thing*, but an extension and intensification of the normal mark.

Is there any explanation for this? I can account for it only by referring it to the hard time the bird passed during the first 2 or 3 days of its life. . . . It may be that the *lack of food* for the first two days was the cause of this enlarged mark—a sort of albinism.⁶ (CC 0)

It will be seen from table 93 that the "mutant" was bred when 1 and 2 years of age to a male *Zenaidura carolinensis*. The "mutant" offspring in this cross seem to arise chiefly from the stronger germs.

³ See Chap. IX, Vol. I.

⁴ The original records for the breeding of *Z. vinacco-rufa* are not available to the editor; the descriptions in connection with the *Zenaida* "mutant" and of the several *Zenaida* hybrids form most of the materials at hand.—EDITOR.

⁵ This prediction proved entirely true.—EDITOR.

⁶ In a note dated two years later (in 1908) Whitman wrote: "This 'mutant' (21) hatched *September 28, 1906*, from the *second* egg of the clutch," underlining the words "September" and "second." In view of the other data then at hand on the relation which both season and the order of the eggs of clutch bear to the "strength of germs" it seems certain that these points were at the latter date, to his mind, the most important considerations bearing upon the appearance of this "mutation." At this later date he had also found, of course, that the mutational character was *inherited*, and was, therefore, not a phenomenon of merely transitory and somatic value.—EDITOR.

This mutant (21) hatched *September 28, 1906*, from the *second* egg of the clutch. . . . In the midst of a mating with a mourning-dove she was noted on July 9, 1908, to have weak legs (probably she was weakening before this was observed). In her breeding she began strongly to transmit her juvenal (mutant) pattern, but as she weakened the male gained control and produced the normal type (*italics are the author's*). (K, C 000)

The result of breeding from the first of the daughter "mutants" is given in table 94. It is clear that the mutational mark was strongly inherited in this the second generation. Its inheritance in the third generation is shown under pair 2 of the same table.⁷ A glance at table 95 will show that one of the normal daughters of the original mutant gave no evidence of power to produce mutants when mated with a complex *Zenaida* × *Zenaidura* hybrid.

The several succeeding tables already referred to in another connection show that none of the many combinations of *Zenaida*, *Zenaidura*, or of their hybrids⁸ give any suggestion of forms similar to mutant No. 21 and her mutant progeny.

In this *Zenaida* mutation (No. 21), then, we have to do with a striking departure from the normal, with a character which exists in the juvenal plumage only, with a character which is firmly fixed in heredity; and the bird which originally displayed this character was known to have originated from a germ which was developed under those conditions which have elsewhere shown themselves to be associated with "weakness" of germs.

The data on the inbreeding of three pairs of *Zenaida-Zenaidura* hybrids (matings of brother and sister) are given in table 97. The result, in all the matings, is a low fertility and a shortened life-term of the offspring.

An analysis of the sex-data obtained from all of the matings recorded in this chapter is attempted in table 99. Three points are considered: (1) the sex-ratio (upper row) from (a) pure-bred matings, from (b) matings of hybrid males with pure-bred females, (c) various hybrid combinations (two groups); (2) the ratio of males to females (middle row) from eggs laid before July 1; and (3) the relation of the order of eggs in the clutch (lower row) to sex, in mating in which (a) pure females and (b) hybrid females were the producers of the eggs.

By reference to the table it will be seen that in matings of *carolinensis* × *carolinensis* the ratio of males to females is 10 ♂ : 12 ♀. When crosses were made, using pure (not hybrid) females (*carolinensis* and *vinaceo-rufa*), this ratio was 20 ♂ : 14 ♀. From crosses in which the female is hybrid the ratio was 15 ♂ : 14 ♀. The corresponding figures prior to July 1 are, 4 : 6, 11 : 7, and 8 : 4. The relation of sex to egg of clutch is of interest, and the effect of hybridization upon this order is well shown. Pure-bred females produced the two sexes in each of 15 clutches; 12 of these threw males from the first and females from the second egg, the reverse in 3 cases. But hybrid females yielded 6 such pairs in which only 3 threw the sexes in the more usual order, and in an equal number of pairs this order was reversed.

⁷ This stock has been maintained by the editor since 1910, and has thrown normals and mutants much as in the record given above. The breeding of the "mutant" series was actively done during 1911, 1912, and 1915. A further statement concerning the later results will at some time be published.—EDITOR.

⁸ *Zenaida* and *Zenaidura* present several contrasting characters to which slight reference is made in the tables. It will be noted that for most of these characters Whitman had found that the characters "fractionated," and that even in the F₂ and complex hybrids there was often little evidence of segregation. One of these hybrids is shown in pl. 20.—EDITOR.

This group of birds, like other groups already considered, indicates, therefore, that in females of pure species—not hybrid—the order of the eggs in the clutch is correlated with sex. There are, too, plain indications here as elsewhere that not only does the act of (wide) hybridization affect the sex-producing capacity of a given pair or group of eggs from pure parents, but in the resulting hybrids the normal relations between sex and the order of the eggs is also affected or modified.

TABLE 89.

Pair A.

♂ *Zen. carolinensis* (2); from dealer (very young) in 1896.♀ *Zen. carolinensis* (2); from dealer (very young) in 1896.

♂ A 1. 4/26/97.....alive 4/29/99.....24+ mo.	
♀ A 2. 4/28/97.....escaped 4/29/99.....24+ mo.	
♂ B 1. 5/27.....hatched.	D 1. 7/14.....dead 8/4/97 at 6 days.
♀ B 2. 5/29.....hatched.	♂ D 2. 7/16.....killed 10/16/97.....3 mo.
C. 6/26.....thin shell, broken.	♀ E 1. 8/18.....dead 7/20/98.....11 mo.
	♀ E 2. 8/20.....dead 10/20/97.....2 mo.
F 1. 3/8/98.....thin shell, broken.	
F 2. 3/10/98.....thin shell, broken.	
G. 4/2.....thin shell, broken.	♂ J 1. 6/2.....dead 2/18/00.....20½ mo.
H 1. 4/9; broken.	J 2. 6/4; no record.
H 2. 4/11; broken.	♂ K 1. 7/3.....dead 1/1/00.....18 mo.
I 1. 4/24.....died on trip at 2½ weeks.	♀ K 2. 7/5.....hatched.
I 2. 4/26.....not hatched.	♀ L 1. 7/30.....hatched.
LL 1. 3/?/99.....soft shell.	♂ L 2. 8/1.....alive 5/7/01.....33+ mo.
LL 2. 3/?/99.....soft shell.	♀ O 1. 6/27.....dead 12/24/99.....6 mo.
M 1. 4/24; no development.	O 2. 6/29.....probably not hatched.
M 2. 4/26; no development.	P 1. 7/29.....dead 10/6/99.....2 mo.
♀ N 1. 5/28.....dead 12/16/99.....6½ mo.	P 2. 7/31.....hatched.
♀ N 2. 5/30.....dead 12/29/99.....7 mo.	
Q 1. 4/13/00.....soft shell.	S 1. 6/10.....hatched.
Q 2. 4/15/00.....soft shell.	S 2. 6/12.....hatched.
R 1. 5/2.....killed by parents at 1 day.	T 1. 7/12.....hatched.
R 2. 5/4.....died at 1 week.	♀ T 2. 7/14.....dead 1/20/01.....6 mo.

(CC 13, EM 7)

TABLE 90.

Pair B.

Zen. carolinensis (1); hatched 1896; dead 8/?/99; 36 mo.*Zen. carolinensis*; from dealer May 1896; dead 4/27/98; 24+ mo.

A. 3/24/97; broken.	B 1. 4/18; apparently not tested.
C 1. 5/10; developed nearly to hatching (disturbed).	B 2. 4/20; apparently not tested.
C 2. 5/12; hatched, dead (exposure) at 3 days.	
D 1. 6/4; no record.	G 1. 7/1/97; lost on trip.
D 2. 6/6; no record.	G 2. 7/3/97; lost on trip.
E. 6/14; broken.	♂ H 1. 7/20; hatched, exposed, died at 11 days.
F. 6/23; thin shell, broken.	H 2. 7/22; hatched, dead 11/9/97; 3½ mo.

(EM 7, C 7-22)

Pair C.

♂ *Zen. carolinensis* (2-A 1); 5/11/97; brother; (death?).♀ *Zen. carolinensis* (2-A 2); 5/13/97; sister; escaped 4/29/99.

"One or two clutches laid with thin shells," then:

A 1. 6/8/98.....hatched.....dead about 7/20/98.....6 weeks.	
A 2. 6/10/98.....hatched.....dead about 7/20/98.....6 weeks.	
B 1. 7/10.....hatched.....dead 8/20/98.....41 da.	
B 2. 7/12.....hatched.....dead 8/20/98.....39 da.	
♂ C 1. 8/4.....hatched.....dead 10/28/98.....3 mo.	
♀ C 2. 8/6.....hatched.....(killed) 1/4/99.....5+ mo.	
D 1. 4/26/99; probably did not hatch.	
D 2. 4/28/99; probably did not hatch.	(CC 9)

TABLE 90 (continued).

Pair D.

♂ *Zen. carolinensis* (1); 1904 or earlier.♀ *Zen. carolinensis* (1); 1904 or earlier.

A 1. 5/4/05.....5.....	no later record.	B 1. 6/9; deserted.
A 2. 5/6/05.....6.....	dead 1/22/06.	B 2. 6/11; deserted.
C 1. 7/5*.....9.....	dead 9/15/05.	
C 2. 7/6*.....10.....	dead 12/16/05.	
D 1. 7/31.....13.....	probably died early.	
D 2. 8/2.....14.....	dead 9/23/05.	

Pair E.

♂ *Zen. carolinensis* (C 3).♀ *Zen. carolinensis* (2); 1904 or earlier.

♀ A 1. 5/8/06*.....10.....	killed (accident) at 10 weeks.
A 2. 5/8/06*.....10.....	no later record.
♂ B 1. 5/27.....11.....	alive 8/2/08.
B 2. 5/29.....11.....	dead 8/18/06.

Pair F.

♂ *Zen. carolinensis* (PP 3); taken wild near Chicago, 6/6/07.♀ *Zen. carolinensis* (S. M. 1); from Santa Martha, U. S. Colombia, 5/29/07.

A 1. 6/16/08*; thrown from nest.	♂ B 1. 7/18*; 21; dead 12/4/08.	C 1. 8/9*; 22.
A 2. 6/17/08*; 20; no later record.	B 2. ; did not hatch.	C 2. 8/10; 23.

* Indicates date of hatching

(Sh. 28).

TABLE 91.

♂ *Zenaida vinaceo-rufa*.¹♀ *Zenaidura carolinensis*.

♂ A 1. 4/10/05.....ZZ 1.....	dead 3/22/09.....	47 mo. (see pl. 20).
♀ A 2. 4/12/05.....ZZ 2.....	dead 6/18/06.....	14 mo.
♂ B 1. 5/10.....ZZ 3.....	dead 7/16/06.....	14 mo.
♂ B 2. 5/12.....ZZ 4.....	dead 9/13/09.....	52 mo.
♂ C 1. 5/18.....ZZ 5.....	alive 10/1/14.....	113+ mo.
♀ C 2. 5/20.....ZZ 6; "color indicates it is a ♀,"	disappeared or dead before 2/5/11.	
D 1. 6/19; developed embryo, deserted.	E 1. 7/7; no development.	
D 2. 6/21; developed embryo, deserted.	♂ E 2. 7/9.....ZZ 7.....	alive 5/21/07.....22+ mo.
F 1. 8/4 } one broken, other developed, but was deserted.		
F 2. 8/6 }		
♀ G 1. 8/13.....ZZ 8.....	alive 6/1/09.....	46+ mo.
♂ G 2. 8/15.....ZZ 9.....	dead (fright) 7/30/07.....	24+ mo.
♀ H 1. 9/30.....hatched.....	dead 2/26/06.....	5 mo.
♂ H 2. 10/2.....hatched.....	dead 1/4/06.....	3 mo.

I. 1/26/06; did not hatch.

J.; a dwarf egg.

K. 4/4/06; did not hatch.

♀ L 1. 4/16.....ZZ 10.....	dead 2/23/08.....	22 mo.
L 2. 4/18.....ZZ 11.....	no later record.	
M 1. 5/16; failed to develop (possibly deficient incubation).		
M 2. 5/18; failed to develop (possibly deficient incubation).		
N 1. 6/9.....hatched; died early.	♂ O 1. 7/25 (hatch.).....ZZ 12.....	matured, mated.
N 2. 6/11.....hatched; died early.	♀ O 2. 7/26 (hatch.).....ZZ 13.....	alive 10/10/06.
P 1. 8/7.....hatched.....	died at 1 day (care ?).	
♂ P 2. 8/9.....ZZ 14.....	alive 8/3/08.....	24+ mo.

¹ It is not absolutely certain that this *Zenaida* was *vinaceo-rufa*.—EDITOR.

(CC 3)

TABLE 92.—Reconstructed¹ breeding record of *Zenaida vinaceo-rufa*, 1905-6.

Pair 1.

♂ *Zenaida vinaceo-rufa* (2); (imported, probably from Venezuela, 1904).♀ *Zenaida vinaceo-rufa* (2); (imported, probably from Venezuela, 1904).

♀ and ?	{ ? 1. 5. 26 05* 11.	normal; dead 3 ? 07.
	{ ? 2. 5. 27 05* 12.	♀ normal, shade darker than 13 (see pl. 83, Vol. I).
	{ ? 1. 6. 24* 13.	normal, shade lighter than 12.
	{ ? 2. 6. 25* 11.	normal ? or weak mutant ?, shade lighter than 13.

Pair 2.

♂ *Zenaida vinaceo-rufa* (0); imported, from Venezuela 1905.♀ *Zenaida vinaceo-rufa* (12); 5/27/12 (see above, and pl. 83, Vol. I).

? } 8/18/06* 20. normal, alive 6/10/07 (see pl. 84, Vol. I).

? 1. 8/12(?); not hatched.

♀ ? 2. 9/28/06* 21. ♀ MUTANT; dead 9/21/08 (see pl. 84, Vol. I).

¹ Complete records were of course made by the author, and I find specific references to them; but unfortunately they are not available to the editor. The tabulation represents that part of the record which is repeated; either in summary comment, on breeding records (where these offspring were used as parents), or in legends for illustrations, etc. The interrogation points in the first column indicate that the number of eggs which had been laid during the season prior to the egg described, is unknown.—Editor.

* Indicates date of hatching.

TABLE 93.—The breeding of "mutant" *Z. vinaceo-rufa* No. 21.♂ *Zenaidura carolinensis* (11); 5/27/06.♀ *Zenaida vinaceo-rufa* MUTANT (21); hatched 9/28/06; 9/21/08; 24 mo. (see pl. 84, Vol. I).

♀ A 1.	7/15/07.....	Z-ZN 1.....	"mutant" on breast, lower neck, sides of head.....	10/11/11....	51 mo.
A 2.	7/17/07.....	Z-ZN 2.....	normal.....	12/5/07....	4½ mo.
B 1.	3/21/08; failed to hatch (exposure).				
B 2.	3/23/08; failed to hatch (exposure).				
♀ C 1.	3/28.....	Z-ZN 3.....	"mutant," strong except at bend of wings and back; 5/17/08.....	1 mo.	
C 2.	3/30.....	Z-ZN 4.....	relieved, died before feathering.....	½ mo.	
♂ D 1.	4/10.....	Z-ZN 5.....	mutant, strong on head, breast and wings.....	1/25/10.....	21½ mo.
♀ D 2.	4/12.....	Z-ZN 6.....	normal or nearly.....	3/19/10.....	23 mo.
♂ E 1.	4/24.....	Z-ZN 7.....	normal, like D 2.....	10/1/10.....	29 mo.
E 2.	4/26.....	Z-ZN 8.....	normal, like D 2.....	6/9/08.....	1½ mo.
F 1.	5/14; developed near to hatching, but parents deserted.				
F 2.	5/16; developed near to hatching, but parents deserted.				
G 1.	6/19; "development not completed."				
G 2.	6/21; "development not completed."				

"I now notice (7/9/08) that the dam (21) is not quite well—legs weak; this continued¹ till death (9/21/08)."

♀ H 1. 7/11..... Z-ZN 9..... normal..... 1/20/09..... 6 mo.

H 2. 7/13; fully developed embryo, thrown from nest and broken.

I 1. 7/31; "failed to develop."

I 2. 8/2; "failed to develop."

(K, CCOO)

¹ "The weakening probably began some time before noticed. This female (21) began strongly transmitting her juvenile pattern, but as she weakened the male gained control, and produced the normal type."

TABLE 94.—The breeding of the offspring of the *Zenaida* mutation.

Pair 1.

♂ *Zenaida-Zenaidura* × *Zenaida* hyb. (ZZ-ZN 1); 5/12/07; disappeared or dead before 2/7/11; normal color.♀ *Zenaidura* × *Zenaida* ("Mutant" Z-ZN 1; 7/15/07; dead 10/11/11).

A 1.	7/4/09* (= 2 Z-3 ZN 1.....	color normal, dead 7/18/09.....	14 da.
A 2.	7/4/09* (= 2 Z-3 ZN 2.....	mutant..... strongly marked.....	dead 7/15/09..... 11 da.
B 1.	Did not hatch.		
B 2.	8/14*.....	2 Z-3 ZN 3.....	normal color..... alive 2/7/11..... 18+ mo.
♀ and ?	{ C 1. 9/9* (one = 2 Z-3 ZN 4 ♀.....	mutant.....	dead 11/11/11..... 26 mo.
	{ C 2. 9/9* (one = 2 Z-3 ZN 5.....	normal color.....	dead 6/?/10..... 9 mo.

* Indicates date of hatching.

TABLE 94 (continued.)

D. 2/10/10; soft shell.		E 1. 2/20; thin shell.
		E 2. 2/22; laid on floor, broken.
F 1. 4/3.....	2 Z-3 ZN 6.....	mutant.....disappeared 2/7/11-11/4/13.....12+ mo.
F 2. 4/5; did not hatch.		
♂ G 1. 5/24*.....	2 Z-3 ZN 7.....	mutant.....dead 1/15/14.....44 mo.
♂ G 2. 5/26*.....	2 Z-3 ZN 8.....	mutant.....alive 10/1/14.....52+ mo.
♀ H 1. 6/25*.....	2 Z-3 ZN 9.....	mutant.....dead 6/7/13.....35 mo.
H 2. 6/25*.....	2 Z-3 ZN 10.....	mutant.....dead 7/19/12.....24½ mo.

(H, I, CC 000)

Pair 2.

♂ Zenaida × Zenaida-Zenaidura × Zenaida hyb. (3 ZN-Z 2); 7/7/09; 6/16/14; 59 mo.

♀ Zenaida-Zenaidura × Zenaida × Zenaidura-Zenaida "mutant" hyb. (2 Z-3 ZN 4); 7/15/07; 52 mo.

♀ A 1. 5/28/10... 3 Z-6 ZN 1....."mutant" head, neck, breast and beneath; alive¹ 10/1/14.

A 2. 5/30/10... 3 Z-6 ZN 2.....normal color.

"Some eggs laid that failed between June and September."

B 1. 9/11..... 3 Z-6 ZN 3....."strong mutant."

B 2. 9/13..... 3 Z-6 ZN 4....."good, but little weaker mutant."

(Misc. 2, XX 6)

* Indicates date of hatching.

¹ One bird with this mark is recorded as a female, dead 1/17/12, but a bird (also female) still lives (10/1/14) bearing this tag.—EDITOR.

TABLE 95.—Further breeding of the offspring of the Zenaida "mutation."

♂ Zenaida-Zenaidura × Zenaida hyb. (ZZ-ZN 14); 5/29/08; 4/25/10; 23 mo.

♀ Zenaidura × Zenaida (normal) hyb. (Z-ZN 6); 4/12/08; 3/19/10; 23 mo.

"Three young during 1909, which I mark as follows (no record of time of laying or hatching):"

♀ ZA; fertile (w. ZZ 5). ♂ ZB; fertile (w. 3 ZN-Z 1). ? ♀ ZC.

(H)

♂ Zenaida × Zenaidura hyb. (ZZ 5); (paternal grand-sire of present mate).

♀ ZA (see immediately above) hyb. 1909; escaped about 7/1/11; 24+ mo.; granddaughter.

♂ and ? { A 1. 5/10/10 } one 3 Z-4 ZN 1.....normal (i.e., not "mutant") 14 rectrices; dead 11/12/11(♂).
 { A 2. 5/12/10 } one 3 Z-4 ZN 2.....normal (i.e., not "mutant") 14 rectrices.

♂ B 1. 6/14..... 3 Z-4 ZN 3.....normal color.....14 rectrices.....dead 8/31/10.....2½ mo.

♂ B 2. 6/16..... 3 Z-4 ZN 4.....normal color.....escaped 7/6/13.....37+ mo.

C 1. 7/?; was not hatched.

D 1. 7/?; broken.

C 2. 7/?; was not hatched.

D 2. 7/?; broken.

♀ D 1. 7/21..... 3 Z-4 ZN 5.....normal.....14 rectrices.....dead 11/19/10 (cold ?).....4 mo.

D 2. 7/23..... 3 Z-4 ZN 6.....normal.....14 rectrices.

(Two clutches marked D)

♂ E 1. 9/18..... 3 Z-4 ZN 7.....normal.....14 rectrices; disappeared 11/4/13-10/1/14.....39+ mo.

♀ E 2. 9/20..... 3 Z-4 ZN 8.....normal.....14 rectrices; dead 10/16/10.....1 mo.

♂ ZB (for composition see second section above, this table); hyb. 1909.

♀ Zenaida × Zenaida-Zenaidura × Zenaida hyb. (3 ZN-Z 1); 7/5/09; 11/17/13; 54½ mo.

Both parents have 14 tail feathers.

♀ A 1. 6/14/10... 3 Z-6 ZNA.....color normal, 15 rectrices; 8 right, 7 left; alive 10/1/14.....52+ mo.

♂ A 2. 6/16/10... 3 Z-6 ZNA.....color normal, 14 rectrices; dead 7/24/12.....25 mo.

♂ and ? { B 1. 8/22..... 3 Z-6 ZNB.....normal¹.....14 rectrices; dead 7/17/12.....23 mo.

{ B 2. 8/24..... 3 Z-6 ZNB.....normal.....14 rectrices; dead 9/4/12(♂).....24½ mo.

¹ The original data for some later (known and living) offspring of this composition are not available to the editor.

TABLE 96.

♂ Zenaida × Zenaidura hyb. (ZZ 1); 4/10/05; 3/22/08; 35 mo.

♀ Zenaida (2).

A 1. 4/30/07.....ZZ-ZN 1.....dead very early, but data not recorded.

A 2. 5/2/07.....ZZ-ZN 2.....hatched "seemed well, but dead 6/25/07," at 9 days.

♂ B 1. 5/12.....ZZ-ZN 1.....mated (fertile) disappeared or dead before 2/5/11.

B 2. 5/14; did not hatch.

C 1. 6/3.....ZZ-ZN 2.....dead before 2/5/11.

C 2. 6/5.....ZZ-ZN 3.....dead 11/12/07.....5 mo.

♂ D 1. 7/25.....ZZ-ZN 8.....mated (fertile) tuberculosis; killed 9/12/08.....14+ mo.

♂ D 2. 7/27.....ZZ-ZN 9.....dead 11/9/07.....3½ mo.

♂ E 1. 9/1.....ZZ-ZN 10.....dead 11/3/09.....26 mo.

♀ E 2. 9/3.....ZZ-ZN 11.....tail short, feathers pointed; dead 11/16/07.....2½ mo.

(CC 2)

TABLE 96 (continued).

♂ Zenaida × Zenaidura hyb. (ZZ 5); 5/18/05; alive 10/1/14; 113+ mo.

♀ Zenaida vinaceo-rufa (10); hatched 5/26/05.

♂ A 1. 6/1/07.....	ZZ-ZN 4.....	dead 10/21/11.....	52 mo.
♀ A 2. 6/3/07.....	ZZ-ZN 5.....	disappeared between 7/5/11 and 11/4/13.....	50+ mo.
♂ B 1. 8/4.....	ZZ-ZN 6.....	dead 9/27/10.....	38 mo.
♀ B 2. 8/6.....	ZZ-ZN 7.....	"typical $\frac{3}{4}$ hybrid"; dead 12/13/07.....	4 mo.

C 1. 4/2/08; not hatched (care?).

C 2. 4/4/08; not hatched (care?).

♂ D 1. 5/13.....	ZZ-ZN 12.....	disappeared ¹ between 7/5/11 and 11/5/13.....	40+ mo.
♂ D 2. 5/15.....	ZZ-ZN 13.....	alive 10/1/14.....	77+ mo.
♂ E 1. 5/29.....	ZZ-ZN 14.....	dead 4/25/10.....	23 mo.
♀ E 2. 5/31.....	ZZ-ZN 15.....	(fertile, see below); dead 1/25/10.....	20 mo.

(CC 1, CC 2)

♂ Zenaida vinaceo-rufa (6); imported 1907.

♀ Zenaida-Zenaidura × Zenaida hyb. (ZZ-ZN 15); 5/31/08; 1/25/10; 20 mo.

A 1. 5/1/09; failed to hatch.

A 2. 5/3/09.....ZN-ZZ-ZN 1.....died at end of two weeks; not well fed.

♀ B 1. 7/5.....	3 ZN-Z 1.....	dead 11/17/13.....	52½ mo.
♂ B 2. 7/7.....	3 ZN-Z 2.....	dead 6/16/14.....	59 mo.

(CC 5)

¹ This bird functioned as a male and laid no eggs, but there was no autopsy.

TABLE 97.

Pair 1.

♂ Zenaida × Zenaidura hyb. (ZZ 3); 5/10/05; 7/16/06; 14 mo.; brother.

♀ Zenaida × Zenaidura hyb. (ZZ 2); 4/12/05; 6/18/06; 14 mo.; sister.

A 1. 5/9/06.....hatched, dead at 10 to 12 days.

A 2. 5/11/06.....hatched, dead at 10 to 12 days.

(CC 3, Misc. 1)

Pair 2.

♂ Zenaida × Zenaidura hyb. (ZZ 7); 7/9/05; brother.

♀ Zenaida × Zenaidura hyb. (ZZ 8); 8/13/05; sister.

A 1. 5/?/06; did not hatch.

A 2. 5/?/06; did not hatch.

B 1. 6/11; no development.

B 2. 6/13; hatched; dead at 2 days (accident?).

♀ C 1. 9/14.....	ZZ-C.....	(fertile), mated; probably dead 5/10/09.....	32 mo.
C 2. 9/16.....	hatched; thrown from nest; killed.		

D 1. 4/3/07; did not develop (care?).

D 2. 4/5/07; did not develop (care?).

E 1. 4/26; deserted.

E 2. 4/28; deserted.

F 1. 5/19/07.....ZZ-F.....probably matured.

F 2. 5/21/07.....ZZ-F.....dead on ground at 7 days old.

(Misc. 1, CC 3)

Pair 3.

♂ Zenaida × Zenaidura hyb. (ZZ-9); 8/15/05; dead (fright) 7/30/07; 24+ mo.; brother.

♀ Zenaida × Zenaidura (ZZ-10); 4/16/06; dead 2/23/08; 22 mo.; sister.

A 1. 4/2/07.....ZZ-A.....no later record.

A 2. 4/4/07.....hatched, died at about 1 week, not well fed.

B 1. 4/29; no development.

B 2. 5/1.....ZZ-B....."genuine hybrid; intermediate".....dead 12/12/07.....7½ mo.

C 1. 5/21.....ZZ-C 2.....no later record.

C 2. 5/23.....no record; probably not hatched.

♀ D 1. 7/6.....ZZ-D.....light, "toward Zenaidura"; probably died 10/20/07.....? 3½ mo.

♂ D 2. 7/8.....ZZ-D....."darker, intermediate like parents"; 1/5/08.....6 mo.

(CC 1, CC 3)

TABLE 98.

Pair 4.

♂ Zenaida × Zenaidura hyb. (ZZ 14); 8/7/06; alive 8/3/08; 24+ mo.

♀ vinac.-carolin. × vinac.-carolinensis hyb. (C); 9/14/06; alive 4/1/09; 31+ mo.

A 1. 4/28/07; deserted.	B 1. 5/12; deserted.	C 1. 5/19; deserted.
A 2. 4/30/07; deserted.	B 2. 5/14; deserted.	C 2. 5/21; deserted.
D 1. 5/28.....ZZ-C-D.....	dead 6/14/07 (not fed).	
D 2. 5/30.....	developed, but shell slightly broken, failed.	
♀ E. 7/1.....ZZ-C-E.....	"typical intermediate".....	
	dead 11/21/07.....	5 mo.
♂ F 1. 8/13.....ZZ-C-F.....	"like parents".....	
	dead 11/27/07.....	3½ mo.
♀ F 2. 8/15.....ZZ-C-F.....	dead 2/20/09.....	
		18 mo.
G 1. 3/26/08.....	one failed, other broken.	
G 2. 3/28/08.....	H 1. 4/8; failed to hatch.	
	H 2. 4/10; hatched; dead at 7 to 10 days.	
I 1. 5/5.....ZZ-C-I-r.....	dead 5/10/09.....	
		12 mo.
I 2. 5/7.....ZZ-C-I-l.....	thrown from nest, killed, early.	
J 1. 6/8; hatched.*	K 1. 7/14; hatched.*	
J 2. 6/10; hatched.*	K 2. 7/16; hatched.*	
♂ L 1. 8/1.....ZZ-C-H.....	dead 10/20/08.....	
		2½ mo.
L 2. 8/3.....	"do not know result."	

Next and last egg from this pair 4/1/09.

(CC 1)

Pair 5.

♂ Zenaida-Zenaidura × Zenaida hyb. (ZZ-ZN 2); 6/3/07; dead or disappeared before 2/5/11.

♀ Zenaida-Zenaidura hyb. (ZZ 8); 8/13/05.

♂ A 1. 4/25/08.....	2 ZZ-ZN 1.....	dead 5/23/11.....	37 mo.
♀ A 2. 4/27/08.....	2 ZZ-ZN 2.....	dead 8/1/08.....	3 mo.
B 1. 6/20.....	2 ZZ-ZN 3.....	died very young.	C 1. 7/21; hatched, died early.
B 2. 6/22.....	2 ZZ-ZN 4.....	died very young.	C 2. 7/23; hatched, died early.
(CC 4)			
A (?) a young.....	2 ZZ-ZN 5.....	hatched 6/1/09; dead or disappeared before 2/5/11.	

Pair 6.

♂ Zenaida-Zenaidura × Zenaida hyb. ZZ-ZN 8; 7/25/07; killed (tuber.) 9/12/08; 14 mo.

♀ Zenaida-Zenaidura × Zenaida hyb. ZZ-ZN 5; 6/3/07; disappeared after 50 mo.

Paternal (Zenaida) grandparents of these birds were brothers. They are themselves brother and sister.

A 1. 5/29/08.....	ZZ-ZNA.....	dead 11/17/09.....	17½ mo.
A 2. 5/31/08.....	no record, probably not hatched.		
♂ B 1. 6/14.....	ZZ-ZNB.....	14 rectrices.....	dead 42/2/09.....
			8 mo.
B 2. 6/16.....	hatched.....		
	died in nest.		
C. 8/6.....	ZZ-ZNC.....	dead 12/18/09.....	16½ mo.

* Young thrown from nest (fright) and killed.

¹ Offspring = ½ Zenaida - ½ Zenaidura.

(CC 7)

TABLE 99.—Sex-ratio in breeding and crossing of mourning-doves with Zenaida.

I Car. × Car.		II Zen. × Car.		III Car. × Zen.		IV Hyb. × Zen.		V Total.		VI Zen. × Hyb.		VII Hyb. × Hyb.		VIII Comp. Hyb.		IX Total.	
♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
10	12	9	6	2	4	9	4	20	14	1	1	1	2	13	11	15	14
No. of males and females before July 1.																	
4	6	4	3	2	2	5	2	11	7	0	0	0	0	8	4	8	4
Pairs of eggs in which first egg produced male, second egg female (A); and reverse (B).																	
A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B		
1	1	3	2	1	0	4	0	8	2	0	1	0	1	3	1	3	3

Total for pure females (A-B), 12 to 3. Total for hybrid females, 3 to 3.

CHAPTER XI.

BLOND AND WHITE RING-DOVES CROSSED WITH MOURNING-DOVES, COMMON PIGEONS, AND THE EUROPEAN TURTLE-DOVE.

The three groups of crosses presented here afford an additional opportunity to observe the following facts or situations: (1) the reduced fertility which follows from the mating of forms more and more separated phylogenetically; (2) the appearance of males exclusively in the progeny resulting from the most distantly related crosses; (3) the effects of season and hybridism on fertility and sex, and in isolated instances of the effect of season on the dominance of color.¹

The same forms—blond and white ring-doves—were mated to mourning-doves, which are classed in a different subfamily, with common pigeons, which belong to a different family, and with the European turtle-dove, which belongs to a related genus. The generic and subfamily crosses were more fertile than those of family difference, and from the crosses of genera both male and female young were obtained. The crosses involving birds of different families gave only male offspring, except in two isolated instances in which hybrid males were used with a female (homer?, stray bird) of uncertain (hybrid?) origin. From these pairs 3 birds were obtained which were classed as females, but this classification was probably based solely upon their *behavior* in copulation; no sex data, obtained at the time of death, can be found for either of these three offspring. The subfamily crosses gave also only male offspring. The generic cross described here is apparently perhaps less fertile than the subfamily cross, due chiefly to the high degree of hybridism involved in the birds used as parents, and to more extensive inbreeding in this series of generic crosses.

Complex hybrids were formed in the various groups, and these afforded opportunity for a study of the possibility of the "splitting" of the very distinct characters of the very distinct parental forms. This particular aspect of the results is, however, separately considered in Chapter XVII. In the crosses of the ring-doves with the turtle-dove there is found a limitation of the inheritance of color by sex. In the first group of crosses a number of birds were used as parents whose exact origin may be obtained from the breeding data which is tabulated in connection with the preceding chapter.

BLOND AND WHITE RINGS CROSSED WITH THE MOURNING-DOVE AND ITS HYBRIDS.

In crosses of the mourning-dove, and of several grades of its hybrids, with the closely related genus *Zenaidura*, all were found (in the preceding chapter) to be almost or quite completely fertile. 12 matings of these forms with other doves which are commonly classed in a different subfamily are here recorded, and a low or an extremely low fertility is found in every case; 5 of these pairs (tables 100 to 102) involve the primary cross—*Zenaidura carolinensis* × *St. risoria*; 4 pairs (tables 103 and 104) are pure *carolinensis* × *risoria-alba* hybrids (F_2 of reciprocal crosses); 2 pairs (tables 105 and 106) are F_1 male *Zenaidura* × *Zenaidura* hybrids mated with female pure *St. risoria* in one case and with pure *St. alba* in the other. A twelfth

¹ It has been found necessary for the editor to write this and other introductory matter for most of the subdivisions of the present chapter.

pair (table 107) is formed of a complex *Zenaida-Zenaidura* hybrid mated to a complex *risoria-alba* hybrid.

It is clear that some of these matings are more fertile than are others; but it is not at all apparent that the primary cross is more fertile or less fertile than the crosses of the hybrids. The differences in the fertility of *individuals* is doubtless a complicating factor here. The dissimilar distribution of the eggs over the seasons, and unequal overwork for some pairs, are other variables which make a comparison difficult. It may usually be observed, however, that there is a much decreased fertility after July.

From none of these matings were female offspring obtained. The matings in which pure females were used yielded 16 males and the hybrid females 6 males. It is of interest to note the number and proportion of young possessing no sex-glands which arose in these fraternities. The pure female parents that gave 16 males produced 1 such young; the hybrid females produced in addition to 6 males, 3 offspring with no gonads, and another with very minute testes or testis-like bodies.

Since the mourning-dove and the mourning \times *Zenaida* hybrid have several very sharply defined color-marks or spots and the blond ring has a uniform coloration, it is of interest to note some features of color inheritance in these hybrids. The mourning-dove is shown in pl. 19; the blond ring has been already seen in pl. 8. The following description applies to one of the hybrids (σ H 1 of April 24, 1900, of table 101) of these two forms.

With regard to "the spots on the tertials it would seem at first sight as if there were 'no traces' whatever. On lifting the feathers, about 3 of the upper tertials are found to have 'dusky areas' on the inner webs, with no distinct outlines, but corresponding in position with the elongated spots of the mourning-dove."

There are no distinct spots on the lesser coverts, but some of them, when lifted, display on the basal half a dusky gray in the place of the spots found in the mourning-dove. These dusky-gray areas are often quite clearly outlined or bounded distally, like the "imprints" I once discovered in the white-wing pigeon (*Melopelia*).

At first glance it would be thought that there is no ring and no iridescence in the hybrid. On closer view, I see that about 4 rows of feathers on the side of the neck (corresponding to

EXPLANATION OF PLATE 20.

A. Juvenal male *Zenaida-Zenaidura* \times *Streptopelia risoria* hybrid (ZZ-R 1). Hatched from egg of May 3, 1908 (table 105). Seven-tenths natural size. K. Hayashi del., July 1908.

Sire: *Zenaida* \times *Zenaidura* hybrid (ZZ 1 of this plate). Dam: *St. risoria*.

The juvenal feathers are much as in juvenal mourning-doves, but considerably lighter (pale edges as in the mourning-doves and ring-doves) and the spots are fewer and duller. *Vestiges* of spots are found on the outer web of the inner tertials and on the inner large coverts. The tail feathers are 12 in number (as in the dam); the two mid-feathers are 0.25 inch longer than other rectrices (this is intermediate to the mourning-doves and the ring-doves), but are rounded (this is toward *Zenaida* and *risoria*) rather than pointed.

B. Adult male *Zenaida* \times *Zenaidura* hybrid (ZZ 1). Hatched from egg of April 10, 1905 (table 91). Seven-tenths natural size. K. Hayashi del., May 1906.

In the juvenal plumage the feathers of the back, wings, neck, breast, and forehead were pale-edged, as in *Zenaidura*. Two dark streaks are present on the sides of the head, above and below the ear-coverts. Legs pale red. The black spots are not quite so numerous as on young mourning-doves. The ground color is that of young mourning-doves, but with a shade more of the reddish brown of *Zenaida*. On the breast feathers (juvenal) there is a reddish mid-streak (as in *Leptoptila*), which is wider at the tip and gradually narrowed inward to a point. The reddish is seen at the middle of the tips of the primaries, though there it is not regular in form as on the breast; this also seen in the primary coverts. *It looks as if this were the way the black center became divided into two lateral spots.* If so, it is essentially as in the common pigeon and in *C. livia*. The nest-mate (ZZ 2) of this bird was quite similar to it.



A



B

A. Juvenal male, *Zenaida-Zenaidura* × *Streptopelia risoria* hybrid. (ZZ-R1). Hatched from egg of May 3, 1908. × 0.7. Hayashi del., July 1908. Sire, *Zenaida* × *Zenaidura* hybrid (ZZ1 of this plate). Dam, *St. risoria*.
 B. Adult male, *Zenaida* × *Zenaidura* hybrid (ZZ1). Hatched from egg of Apr. 10, 1905. × 0.7. Hayashi del., May 1906.

the ring in the ring-dove and to the iridescent area in the mourning-dove) are slightly differentiated in color, having a stronger "vinous" tinge than the other feathers, and having the ends cut a little short and rigid in outline, suggesting the feathers of the ring. These feathers are plainly shorter than other feathers, and in some I notice that one web is cut shorter at the tip than is the other web; in these the ring-differentiation takes effect in *only one web, or in one-half or one-third of one web*. The vinous tinge seems to look plainly towards iridescence, and is in fact slightly iridescent in favorable light. The same description (throughout) applies to hybrid male *I2* of the same series. (A 1, 9)

The description of a *carolinensis* × *alba-risoria* hybrid (A 1, April 8, 1897, of table 103) at the time of its death, 29 days after hatching, is given by the author as follows:

The interesting point in regard to color is the "washed-out appearance of the black spots," and the "reduction in number" of these spots. The general plumage color corresponds with the first plumage of the mourning-dove, but it is notably lighter, as if fading into or towards isabelline. The mother's influence is here apparent. The feathers are all edged with isabelline as in the mourning-dove. The primaries are dark, much as in the mourning-dove, but the edging at the free ends is not so deep and rich.

I note the following concerning the spots: In the young mourning-dove (I have one in hand to compare) the scapulars have each two black spots. In the hybrid these spots are found in a few feathers only, and are half faded out. In mourning-dove young most of the coverts in the upper half of the wing are marked in the same way, the spots becoming larger and more conspicuous posteriorly in the larger coverts. In the hybrid all these spots are absent, or washed out so far as not to be recognizable, except on two of the upper larger coverts, namely, the twelfth and thirteenth, counting upward on the wing. These two feathers have the spot on the outer web, none on inner, and they are smaller than in the mourning-dove, being fully half washed out. Just behind these spots two tertials (tenth and eleventh, counting upward from first secondary) are similarly marked.

In the mourning-dove three tertials (tenth, eleventh, and twelfth) are thus marked, and marked on both webs, with quite conspicuous black spots; the spots on the outer web are the stronger (deeper) black; four of the upper larger coverts (eleventh, twelfth, thirteenth, and fourteenth) are marked, but only one of these (the twelfth) has a spot on the inner web.

The tail of the mourning-dove has 14 feathers, the outermost one of these (on each side) being white; and this feather, together with 3 others, have white tips. In these 4 feathers the extent of the white diminishes gradually until in the fourth most of the tip is ashy blue partly whitened out at the very end. The fifth and sixth feathers are ashy blue throughout (except the bar). The seventh is brown, becoming blue at the base, and without a bar. The outer feather is about four-sevenths as long as the two middle feathers.

The hybrid has 12 tail feathers and thus agrees with the mother. The two middle ones are brown, and taper a little at the end, but far less than in *Zenaidura*.² The outer web of the outer feathers is not "white" but "light ashy blue." The bar, which is similar to that of the mourning-dove, is on feathers 1 to 4, absent on 5 and 6. This outer feather is 80 mm. long; the middle feather is 105 mm. The outer is thus about three-fourths as long as the middle feather. On the under side the bar extends farther towards the base, and a trace of it is seen on the middle feathers. The under tail-coverts are "white," and extend to the outer edge of the bar.

The feathers on the breast—those along the middle line from chin to abdomen—show a vinous tinge similar to those of *Zenaidura*. Elsewhere they are pale brown, edged with isabelline. The color grows lighter backward, whitening out towards the vent. The under wing coverts are pale bluish gray. The eye is dark, but lighter than that of the mourning-dove. The size of the hybrid is clearly between that of mourning- and ring-doves. (CC 16)

² "I have only an adult tail to compare; possibly the difference in the young is less."

The *Zenaida* × *Zenaidura* hybrid (ZZ1) which is used as the sire in table 105 is figured in pl. 20. When this hybrid is compared with the mourning-dove (pl. 19) it is plain that the long tail and the large suborbital spot of the latter have been very perceptibly reduced, and the reddish-brown color increased, in the direction of *Zenaida*. When this hybrid was mated with a blond ring it will be seen by reference to pl. 20 that once more a fair intermediate results—an intermediate not only in the general coloration, but in the specific parts of the color-pattern. The black spots of the *Zenaida* and *Zenaidura* ancestors are again reduced in size and in number toward the uniform color of the ring-dove. The number of tail-feathers (rectrices) in this fraternity was that of the dam (12) in 4 cases, and that of the sire (14) in a fifth individual.

TABLE 100.

♂ <i>Zen. carolinensis</i> (5); hatched 1897.		
♀ <i>St. risoria</i> (b); from dealer early 1898.		
A 1. 5/9/98; no development.	C 1. 6/16; no development.	E 1. 7/13; no development.
A 2. 5/11/98; no development.	C 2. 6/18; no development.	E 2. 7/15; no development.
B 1. 6/3; no development.	D 1. 6/28; probably no development.	F 1. 8/18; no development.
B 2. 6/5; no development.	D 2. 6/30; probably no development.	F 2. 8/20; no development.
♀ <i>St. risoria</i> (C) given early 1899. From dealer March 1898.		
A 1. 4/23/99; no development.	I 1. 12/21; no development.	N 1. 8/18; no development.
A 2. 4/25/99; no development.	I 2. 12/23; no development.	N 2. 8/20; hatched.
B 1. 5/30; hatched, dead 7/12/99; 6 weeks.		O 1. 10/6; no development.
B 2. 6/1; hatched, no later record.	J 1. 5/29/00; no development.	O 2. 10/8; no development.
	J 2. 5/31/00; no development.	P 1. 1/?/01; no development.
♂C 1. 6/30; hatched.	♂K 1. 6/16; hatched; dead 11/1/02 at 29 mo.	P 2. 1/?/01; no development.
♂C 2. 7/2; hatched.	♂K 2. 6/18; hatched; dead 10/20/10 at 4 mo., "no distinct sex- glands."	Q 1. 2/?; no development.
♂D 1. 8/1; hatched.		Q 2. 2/?; no development.
♂D 2. 8/3; dead at 33 mo.	L 1. 7/3; not hatched (♂ does not incubate well).	R 1. 3/2; no development.
E 1. 9/8; no development.	L 2. 7/5; not hatched (♂ does not incubate well).	R 2. 3/4; no development.
E 2. 9/10; no development.		S 1. 4/6; no record.
F 1. 10/6; no development.		S 2. 4/8; no record.
F 2. 10/8; no development.	♂M 1. 7/12; hatched; dead 9/25/00 at 2½ mo.	T. 5/5/01; no record.
G 2. 10/31; no development.	M 2. 7/14; hatched.	U 1. 7/12/01; no record.
G 2. 11/2; no development.		U 2. 7/14/01; no record.
H 1. 11/24; no development.		
H 2. 11/26; no development.		

(CC 11, P 16)

TABLE 101.

<i>Zen. carolinensis</i> (II-L 2); hatched 8/16/98; alive 5/7/01.		
<i>St. risoria</i> (d); from dealer.		
A 1. 5/6/99. apparently did not hatch.	C 1. 7/1; some development.	
A 2. 5/8/99. dead 6/3/99. at 12 da.	♂C 2. 7/3. dead 2/10/03. 43 mo.	
?B 1. 6/2. (sex ?); dead 1/1/06. 7 mo.	♂D 1. 7/31. dead 12/25/99. 5 mo.	
B 2. 6/4. developed nearly to hatching.	D 2. 8/2. a little development.	
♂E 1. 9/5. dead 3/9/03. 42 mo.	F 1. 11/15; no development.	G 1. 12/23; no test.
E 2. 9/7. alive 6/10/02. 33+ mo.	F 2. 11/17; no development.	G 2. 12/25; no test.
♂H 1. 4/24/00. dead 2/28/02. 22 mo.	♂K 1. 8/1. dead 12/11/00. 4 mo.	
H 2. 4/26/00. dead (care). 21 da.	K 2. 8/3; probably not hatched.	
I 1. 5/31. hatched.	L 1. 9/8; no development.	
♂I 2. 6/2. dead 3/1/02. 21 mo.	♂L 2. 9/10. dead 11/25/02. 26½ mo.	
♂J 1. 7/11. dead 5/30/02. 22½ mo.	M 1. 10/?; no development (good care ?).	
J 2. 7/13; no development.	M 2. 10/?; no development (good care ?).	
N 1. 12/?; not well cared for by foster parents.		
N 2. 12/?; not well cared for by foster parents.		
O 1. 1/22/01; no development.	Q 1. 4/5; weak shell, much development.	
♂O 2. 1/24/01. dead (care ?) 3/2/01. at 6 wks.	Q 2. 4/7; hatched.	
P 1. 3/3. dead 4/1/01. at 4 wks.	R 1. 5/3. "died at a few days (care)."	
P 2. 3/5. dead 4/3/01. at 4 wks.	R 2. 5/5. "died at a few days (care)."	

(CC 6, A 14, P 16)

¹ Apparently the sex of this 7-months-old bird could not be ascertained.

TABLE 102.

♂ *Zen. carolinensis* (1-H 1); hatched 9/1/97; 11/4/01; 50 mo.♀ *St. risoria* (C); from dealer March 1898.

A 1. 6/2/98; no development.	D 1. 7/21; no record; probably no development.
A 2. 6/4/98; no development.	D 2. 7/23; no record; probably no development.
B 1. 6/16; no development.	E 1. 7/31; no record; probably no development.
B 2. 6/18; no development.	E 2. 8/2; no record; probably no development.
C 1. 7/4; no development.	
♂C 2. 7/6; hatched; dead 10/18/08 at 3½ mo. ¹	
(Pair separated 8/16/98).	

♀ *St. risoria* (E) given 5/1/99.

A 1. 5/12/99; no development.	B 1. 6/4; probably no development.
A 2. 5/14/99; no development.	B 2. 6/6; probably no development. (CC 14, A 14)

¹ "This hybrid was of a lighter and brighter brown than the other two obtained in same manner. They approached more the color of the male, while C 2 makes a greater advance towards the female. The general color of C above is a light reddish brown."

TABLE 103.

♂ *Zen. carolinensis* (1 ?); hatched 5/15/96; 3/17/97.♀ *risoria-alba* hyb. (XW 2 B 1); hatched 5/30/96.

A 1. 3/7/97; no development.		
A 2. 3/9/97; no development.		
♂ <i>Zen. carolinensis</i> (2) given 3/17/97. ♀ had laid 1 egg 2 weeks before B 1 and B 2.		
B 1. 3/23; no development) because no copulations of	C 1. 5/25; no development.	
B 2. 3/25; no development) this pair.	C 2. 5/27; no development.	
A 1. 4/8; 44 da. (see text); dead 5/22 (care ?).	D 1. 6/7) one developed near to hatching, other prob-	
A 2. 4/10; no development.	D 2. 6/9) ably no development.	
B 1. 5/7; not much development.	E 1. 7/1; no development.	
B 2. 5/9; no development.	E 2. 7/3; no development.	
F. 7/26; no development; probably no second egg.	G 1. 8/11; no development.	H 1. 8/24; no development.
	G 2. 8/13; no development.	H 2. 8/26; no development.
I 1. 2/24/98; J 1, K 1, L 1.	M 1. 4/10; laid without copulations.	N 1. 4/18; no development.
I 2. 2/26/98; J 2, K 2, L 2.	M 2. 4/12; laid without copulations.	N 2. 4/20; no development.
Copulations on and after 4/16/98.		
O 1. 4/30; ? no development.	T 1. 6/26; no development.	X 1. 4/10/99; no development.
O 2. 5/2; no development.	T 2. 6/28; no development.	X 2. 4/12/99; no development.
P 1. 5/17; no development.	U 1. 7/14; no development.	Y 1. 5/21; no development.
P 2. 5/19; no development.	U 2. 7/16; no development.	Y 2. 5/23; no development.
Q 1. 5/30; not tested.	-V 1. 8/19; no development.	Z 1. 5/11; no development.
Q 2. 6/1; not tested.	V 2. 8/21; no development.	Z 2. 5/13; no development.
R 1. 6/7; no record.	(Some sets of eggs with male not sitting, until W).	AA 1. 5/30; no development.
R 2. 6/9; no record.		AA 2. 6/1; no development.
S 1. 6/17; no development.	W. 11/1/98; no development.	BB 1. 6/11; probably no development.
S 2. 6/19; no development.		BB 2. 6/13; probably no development.

(CC 16)

TABLE 104.

Pair 1.

♂ *Zen. carolinensis* (1); hatched 1896; dead 8/7/99; 36 mo.♀ *Alba-ris. × ris.-alba* (D 1); hatched 8/6/97; alive 7/25/99; 24+ mo.

A 1. 6/9/98; a little development.	D 1. 10/?; no development, but ♂ not copulating.
♂A 2. 6/11/98; hatched; dead 1/8/00; 19 mo.	D 2. 10/?; no development, but ♂ not copulating.
B 1. 7/15; no development.	E 1. 11/5; sire copulates, but does not sit.
♂B 2. 7/17; hatched; dead 12/10/00; 29 mo.	E 2. 11/7; sire copulates, but does not sit.
C 1. 8/6; about 7 day embryo.	F 1. 11/18; no record; probably no development.
C 2. 8/8; no development.	F 2. 11/20; no record; probably no development.
G 1. 4/10/99; no development.	
G 2. 4/12/99; no development.	
H 1. 4/22) one dead 11/4/01, at 30½ mo.; one developed.	J 1. 6/26; dead 7/21/99; 3½ wks.
H 2. 4/24) failed.	J 2. 6/28; dead 7/19/99; 3 wks.
I 1. 5/25; not much development.	K 1. 7/23; dead 8/16/99; 3 wks.
I 2. 5/27; dead 7/16/99; 7 wks.	K 2. 7/25; dead 8/16/99; 3 wks.

(C 7/22, P 16)

TABLE 104 (continued).

Pair 2.

♂ *Zen. carolinensis* (4); hatched 9/16/96.♀ *Alba-ris. × ris-alba* hyb. (B 2).

A 1. 4/12/98; not tested.	D 1. 6/3/98; no development.	G 1. 5/31 } one some development,
A 2. 4/14/98; not tested.	D 2. 6/5/98; no development.	G 2. 6/2 } other ? no development.
B 1. 4/20; soft shell.	E 1. 6/17; no development.	H 1. 6/11; no development.
B 2. 4/22; soft shell.	E 2. 6/19; no development.	H 2. 6/13; no development.
C 1. 5/9; no development.	F 1. 5/5/99; no development.	
C 2. 5/11; no development.	F 2. 5/7/99; no development.	

♀ *Zen. carolinensis* (II K 2); 7/5/98 given to above male, June 1899.

A 1. 7/24/99; hatched, no record.	B 1. 8/30; hatched, no record.	
A 2. 7/26/99; hatched, no record.	B 2. 9/1; no trace of development.	(CC 18)

TABLE 105.

♂ *Zenaida × Zenaidura* hyb. (ZZ 1); 4/10/05; 3/22/09; 47 mo.; 14 rectrices.♀ *St. risoria* (purity ?); age not recorded; 12 rectrices.

A 1. 5/1/08; no development.	
♂ A 2. 5/3/08. ZZ-R 1. 12 rectrices, 2 or 3 dull vestiges of spots (see pl. 20).	
B 1. 5/31. ZZ-R 2. ("down" more as in sire).	
B 2. 6/2. "developed near to hatching, strength failed"; (complexion lighter than <i>Zenaida</i>).	
C 1. 7/3. ZZ-R 3. 12 rectrices; 3 traces of spots (tertials); dead 12/5/08. 5 mo.	
C 2. 7/5. developed some days, but failed to hatch.	
♂ D 1. 8/7. ZZ-R 4. dead 9/8/09. 13 mo.	
♂ D 2. 8/9. ZZ-R 5. dead 9/14/09. 13 mo.	
E 1. 9/16. ZZ-R 6. 14 rectrices, short as in <i>Zenaida</i> .	
? E 2. 9/18. ZZ-R 7. 12 rectrices ¹ dead 8/17/09. 11 mo.	
F 1. 1/1/09; failed to hatch.	G 1. 2/13; hatched, thrown from nest; "strong looking," dark.
F 2. 1/3/09; failed to hatch.	G 2. 2/15; nearly hatched (exposure); "strong looking," dark.
H 1. 2/23; hatched; thrown from nest, died.	
H 2. 2/25. ZZ-R 8. 12 rectrices.	(C 5)

¹ "Seems to be a male with two minute globular testes; am unable to be certain of their being testes."

TABLE 106.

♂ *Zenaida × Zenaidura* hyb. (ZZ 4); hatched 5/20/05; 9/13/09; 52 mo.♀ *St. alba* (93) (purity ?).

? A 1. 4/23/08. ZZ-A 1. dark; 14 rectrices; apparently no gonads ¹ 5/24/09. 13 mo.	
A 2. 4/25; developed, but died in shell about 24 hours before time to hatch.	
B 1. 5/23; no record, certainly not hatched.	
? B 2. 5/25. ZZ-A 2. dark; apparently no gonads ² 8/4/09. 14½ mo.	
C 1. 6/21; no development.	
C 2. 6/23; no development.	
D 1. 7/4. ZZ-A 3. dark, not quite as <i>Zenaida</i> ; 14 rectrices ³ 6/3/10. 23 mo.	
D 2. 7/6; no development.	
♂ or ♀ E 1. 9/2. ZZ-A 4. alive 10/1/14. 73+ mo.	
E 2. 9/4. ZZ-A 5. dead or disappeared before 2/5/11.	
F 1. 5/19 } one = ZZ-A 6; no other record; other not hatched.	
F 2. 5/21 }	
G 1. 6/24; no development.	H 1. 7/9; no development.
G 2. 6/26; no development.	H 2. 7/11; no development.
	(CC 8)

¹ "I find no testicles, no ovary. It may be that very obscure rudiments of sex-organs exist, but I can not distinguish anything of that kind."² "I find nothing that looks like testicles or ovary."³ "A marginal chequer (spot) was found on the third tertial of each side, this not quite reaching middle of web and becoming thin and shadowy along inner boundary."

TABLE 107.

♂ *Zenaida-Zenaidura × Zenaida × Zenaidura-Zenaida* (mutant) hyb. (2 Z-3 ZN 3); 8/1/09.♀ *Risoria-alba × risoria-alba* (125).

A 1. 8/15/10. Z-ZNR 1. "one vestigial spot on tertial"; disappeared or dead before 2/5/11.	
? A 2. 8/17/10. Z-ZNR 2. "no vestigial spot seen"; dead 10/25/14; no gonads whatever.	
A 1. 9/1. ZNZ-RA 1. apparently died very early.	
A 2. 9/3. ZNZ-RA 2. apparently died very early.	(EM 9, Misc. 2, XX 6)

B 1 and B 2 "laid about Nov. 5, 1910. Birds still sitting on them Nov. 20, but there is no development; fertility lowered at end of season" (italics are the author's).

BLOND AND WHITE RINGS CROSSED WITH COMMON PIGEONS.

The presentation of the data for crosses of the ring-doves with common pigeons may be prefaced by the following statement³ made in 1898 by the author:

Dr. Günther, of London, wrote me that he had succeeded in getting a few hybrids between the common dove (*C. laticauda*) and the so-called ring-dove (*St. risoria*) and that all the young which he obtained were males. He did not succeed in mating the hybrids with either of the parent species, and adds that they were so disagreeably noisy that his neighbors did not like to have them around; he therefore felt obliged to put them into the Zoological Garden, where they were kept for about 6 years. When the last one died a year or more ago, Dr. Günther kindly sent me the skins. These hybrids were obtained from a white fantail male and a female ring-dove, and apparently all had about the same color, approximating somewhat to the ground-color of the rock-pigeon. Günther mentions no case in which any white appears.

A word or two may be said as to what there is of interest in the study of these pigeon hybrids. One argument was drawn from hybrids a long time ago, namely, that they exhibit the *characters of both parents* and therefore disprove the old preformation doctrine of development. In other words the ovum can not be a preformed pigeon of a distinct species, because fertilization can turn it into something else. That argument has also been used against the more modern idea of preformation, which might perhaps be expressed by pre-organization,—not that adult organs are formed or present in the organism, but that the egg has an oriented organization with a head, so to speak, or with a region anticipating the head, and other regions anticipating other parts. It seems to me that in the study of hybrids we have a very excellent means of approaching the question of whether the egg really represents an organization to begin with. I have found a good many facts in embryology which led me to think strongly that the egg is really an oriented organism. I have found some very puzzling facts in my short experience with hybrids of pigeons.

There have been very diverse opinions offered as to what the hybrid really includes. Some have maintained that the hybrid includes all the characters of both parents. Naudin⁴ says: "A hybrid is a living mosaic work in which the eye can not distinguish the discordant elements, so completely are they intermingled." Darwin states that "it would be perhaps more correct to say that elements of both parents exist in every hybrid in a double developed state, namely, blended together and completely separate."

A brief extract from Darwin⁵ on the possibilities of establishing a new race by crossing is of interest:

"Until quite lately, cautious and experienced breeders, though not averse to a single infusion of foreign blood, were almost universally convinced that the attempt to establish a new race, intermediate between two widely distinct races, was hopeless; they clung with superstitious tenacity to the doctrine of purity of blood, believing it to be the ark in which alone true safety could be found. Nor was this conviction unreasonable; when two distinct races are crossed, the offspring of the first generation are generally nearly uniform in character; but even this sometimes fails to be the case, especially with crossed dogs and fowls, the young of which from the first are sometimes much diversified. As cross-bred animals are generally of large size and vigorous, they have been raised in great numbers for immediate consumption. But for breeding they are found to be utterly useless; for though they may be themselves uniform in character, when paired together they yield during many generations offspring astonishingly diversified. The breeder is driven to despair, and concludes that he will never form an intermediate race. But from the cases already given, and from others which

³ A stenographic report (slightly corrected by the author, and adapted by the editor) of part of a lecture to the Zoological Club, The University of Chicago, March 9, 1898.

⁴ *Nouvelles Archives du Museum*, tom. 1, p. 151.

⁵ *Animals and Plants*, Vol. II, p. 66.

have been recorded, it appears that patience alone is necessary. . . . Within recent times, as far as animals are concerned, the crossing of distinct species has done little or nothing in the formation or modification of our races. It is not known whether the species of silk-moth which have been recently crossed in France will yield permanent races. . . . Some authors believe that crossing is the chief cause of variability—that is, of the appearance of absolutely new characters. Some have gone so far as to look at it as the sole cause; but this conclusion is disproved by some of the facts given in the chapter on bud-variation. The belief that characters not present in either parent or in their ancestors frequently originate from crossing is doubtful."

I think that these quotations express the essentials of what we know about the results of hybridization. Darwin is quite decided in his opinion that it is very difficult to get anything in the hybrid which is not in the parent.

I have already stated that the hybrids which have hitherto been obtained in the case of pigeons are mainly those between the male common pigeon and the ring-dove. No one, so far as I know, has ever succeeded in getting the reciprocal hybrid; that is, the hybrid between the male ring-dove and the female of any of the common races. It is comparatively easy to mate a male common pigeon with the female ring-dove. The ring-dove is a quite small species (the reader may refer to pl. 8). A male homer, such as I now have mated with a ring-dove, would not from preference select a female of the ring-dove species, but the isolation of such a pair is usually all that is necessary to bring about the mating. In this case the male is much the stronger and the female makes no resistance; being much the weaker she would not offer to peek or strike. But when the attempt is made to effect a mating in the reverse order, using the small ring-dove as the male and set him to courting the very large female homer, the male meets with difficulties at once. There is no natural affinity between the two birds, and if the small male does not keep at a proper distance he is likely to be punished at once. After he has received a few blows on his head the male no longer wants to remain in the sight of such a large and offensive bird; he becomes timid and scarcely dares to approach her. Mating in this way, with a small male and a large female, is something so contrary to the common rules of nature that it becomes difficult. It is, however, not at all impossible when one takes it in hand and uses time and a few precautions. It is a very simple process to isolate the two birds and put them where they can not see their own species. At the time of mating pigeons do not know their own species unless it is presented to them. Allowing that the male has a cage of appropriate size, he gets into the habit of getting into the nest-box and calling for a mate. At that time the large female can be caught in one's hands and held up alongside the nest-box. The male will be a little afraid, but any blows with the beak or strokes with the wing can be prevented; and if this be repeated for a week or two, the male becomes accustomed to the sight of the large female and at length welcomes her. When it is clear that the female is ready to mate she can perhaps be trusted, especially if she shows any signs of fondling his head while being held in your hand; she can then be set free in the cage, and if the male keeps on calling she will probably go into the nest-box and the match is practically completed. But all this would not happen in a state of nature.

Of the difficulties of getting these hybrids I want to say just a word further. From one pair beginning May 3, 1896, and ending August 23, 1897, I had 41 eggs and raised only 4 males; only 7 birds hatched; only 14 were fertilized. You can not get enormous numbers of hybrids from the ring-dove and the common pigeon. I have kept a fantail mated with a ring for more than a year and got only 1 bird. This was a white male with 13 feathers in his tail; the father's influence gave one additional feather to the tail of the young. A homer mated for 6 months with a ring-dove supplied but 2 specimens, both males. Only a year ago I succeeded in getting a male *alba-risoria* hybrid mated with a female homer (*C. tabellaria*). The mating was accomplished some time in April (1897), and I got eggs shortly

after with no results. I got eggs again, and from either the second or the third clutch I found that one egg was fertilized;⁶ but about that time I was obliged to travel to Woods Hole and in transit lost the egg. I got more eggs in the summer, some of which were fertilized, and in which development ran on for several days. Some of these seemed very promising, but it all came to naught. Through the entire summer the infertility or degree of development grew worse and worse, until I failed completely to get eggs fertilized at all. I kept the pair to see what the result would be another year, knowing that the possibilities of fertilization are less during the latter part of the season than they are at the beginning. This year (1898) I have already had the good fortune to get two hybrids from this pair. (A 1)

The crosses of ring-doves with common pigeons represent a wider cross than that described in the preceding section of this chapter—family differences here instead of subfamily distinction there. The present records for the wider cross show a decidedly greater amount of infertility than was noted in the earlier series, and correspondingly only males result from these matings, except, as already noted, in two matings (tables 116 and 117) involving a hybrid male parent and a female homer which was possibly a mongrel. Restricted life-terms and abnormalities also reappear in this wide cross. The breeds of common pigeons used for these crosses were the archangel, *admista*, fantail, tumbler, and homer. The records have been grouped in this order and the tabulations given with a minimum of discussion.

Archangel × *ring*.—Tables 108 and 109 present the results of the mating of a male archangel with 6 different females. This bird was almost fully fertile with a related breed, *C. gyrans*; only about one-fourth of the eggs of the 2 pure *St. risoria* (*D 1* and *D 2*) showed any development; 6 tests with another (weak, see below) pure ring (*GF 1*) proved entirely infertile, as did 6 tests with *alba* (*W 2*) and 4 tests with an *alba* × *risoria* hybrid.

Admista × *ring*.—One of the blond ring females (*D 2*) which was mated with the archangel (*Ar I*) was previously twice tested with another common pigeon. With the archangel only 5 of 21 eggs showed any development whatever; 3 hatched, 2 lived 9 to 11 days. With the two other common pigeons she gave a somewhat better result, though still a poor one, as is shown in table 110.

Fantail × *ring*.—The record presented in table 111 shows how little fertile is the widely separated cross *C. laticauda* × *St. risoria*. The small but perceptible influence of the male on the number of tail-feathers (rectrices) in the two hatches (of 44 tests) is of interest. The sire had 19 rectrices, the dam 12. One of the young had 14 tail-feathers—a feather added to each side. The other young had 13, the extra feather being added to the center of the tail. The first young lived only 3 weeks, but “the second hybrid (*K 1*) hatched December 1, 1897 (still alive March 6, 1909),⁷ with 13 tail feathers, and with a slight tilting of the middle feathers. All of these tail-feathers were colored; but when the bird became about 10 years old (1907–8) three of its tail feathers became white in course of molt. The original rectrices were recorded, the color noted, and the feathers plucked and mounted. I still have the mount, but it has been damaged by moths. In 1908 I again plucked and mounted the tail feathers; I have a photograph of the bird and another of the mounted tail.

⁶ After 3 or 4 days of incubation one can readily learn whether an egg has a living and developing young by holding it up to the light.

⁷ Before noting that this was a pedigreed bird it was killed April 5, 1914. It was then healthy and vigorous, though more than 16 years old. Birds of the mother's species—*St. risoria*—probably never live even 10 years. When 2 years old this bird was fertile with a tumbler (see table 113).—EDITOR.

"This is a case where white came in as a result of weakness, due probably to age and possibly to tuberculosis, one joint of the leg being somewhat affected. The extra tail feathers do not represent so many independent elements given by the male, but rather an excess of energy of development manifested at the same region as in the male parent. The sire had 19 tail feathers." (SS 3)

TABLE 108.

♂ *C. illyrica* (ArI).♀ *St. risoria* (D 1); 7/1/95; escaped 10/25/97.

A 1. 2/18/97; hatched, dead 1 day (cold).	E 1. 5/11; probably no development.
A 2. 2/20/97; developed; broken.	E 2. 5/13; probably no development.
B 1. 3/14; no development.	F 1. 6/6; no development.
B 2. 3/16; some development.	F 2. 6/8; no development.
C. 4/6; no development.	G 1. 6/26; no development.
D. 4/29; probably no development.	G 2. 6/28; no development.
H 1. 7/12; no development.	J 1. 8/29; no development.
H 2. 7/14; no development.	J 2. 8/31; no development.
I 1. 8/2; hatched; dead 3½ days.	K. 10/23; probably no development.
I 2. 8/4; pricked shell; failed.	

(C 7/28)

♀ *St. risoria* (GF 1) given about Nov. 1897. Six eggs were produced 12/10/97 to 1/18/98; all proving infertile. This was apparently a "weak" bird, since the records (C 7/20) show she was killed on 1/27/98.—EDITOR.

On 1/21/98 another ♀ *risoria* (D 2) given, with following result:

A 1. 1/28/98} one developed, failed; other probably no	G 1. 7/18; no development.
A 2. 1/30/98} development.	G 2. 7/20; no development.
B 1. 2/19; pricked shell, failed.	H 1. 8/12; no development.
B 2. 2/21; no development.	H 2. 8/14; no development.
C 1. 3/16; no development.	I 1. 8/24; no development.
C 2. 3/18; no development.	I 2. 8/26; no development.
D 1. 4/14; developed 8 to 10 days.	J 1. 9/14; no development.
D 2. 4/16; no development.	J 2. 9/16; no development.
E 1. 5/12; hatched; dead at 11 days.	K 1. 10/5; no development.
E 2. 5/14; no development.	K 2. 10/7; no development.
♂F. 6/11; hatched.	

(C 7/28)

♀ *St. alba* (W 2) given 10/16/98; between this date and December 4, 1899, 6 eggs were produced and all tested absolutely infertile.

♀ *risoria* × *alba* hybrid was substituted early in 1899, and produced 4 infertile eggs with this male.

TABLE 109.

♂ *C. illyrica* (ArI) [before with *risoria* (D 1, GF 1, D 2); *alba* (W 2); and *ris.-alba* hyb.]♀ *C. gyrans*; black parlor tumbler.

A 1. 7/28/99; hatched.	F 1. 2/28; hatched; soon died.
A 2. 7/30/99; hatched.	F 2. 3/2; hatched; soon died.
B 1. 9/13; not tested.	G 1. 3/31; did not hatch.
B 2. 9/15; not tested.	G 2. 4/2; hatched.
C 1. 10/8; hatched, died 8 to 10 days.	H 1. 6/7; not tested.
C 2. 10/10; pricked shell, failed.	H 2. 6/9; not tested.
D 1. 11/22; hatched; soon died.	I 1. 7/9; probably not tested.
D 2. 11/24; hatched; soon died.	I 2. 7/11; probably not tested.
E 1. 1/17; no record.	J 1. 8/19; hatched.
E 2. 1/19; no record.	J 2. 8/21; probably hatched.

(C 7/28)

Tumbler × *ring*.—The very distantly related tumbler pigeon (*C. gyrans*) and the blond ring-dove yield only male offspring (table 112). With a female *risoria* × *alba* hybrid the result was the same, as will be seen in table 114. It will be noted that the amount of absolute infertility in both cases is very great. The distribution of this infertility is of interest in reflecting the influence of "overwork" and lateness of season. The greater developmental power of the first eggs of clutches (except the very first of the season), as compared with the

second, is also well shown when the eggs of the pure species are used. This latter situation is not true of eggs produced by the hybrid *risoria* × *alba*. In the mating of the tumbler with a pure ring the first egg shows greater developmental power in 6 cases, less in 2 cases; and both of these two exceptions pertain to the first clutch of the year. On the other hand, when the same tumbler was mated to a *risoria* × *alba* hybrid the second egg of the clutch showed greater developmental power in 5 cases and less developmental power in 3 cases.

The difficulty of getting hybrids from wide crosses and the added difficulty which arises when either of the members of the cross is itself a *hybrid* is illustrated in the record (table 113) of a *laticauda* × *risoria* male to a female tumbler. Only 3 eggs of 24 tested showed any development. These eggs were from adjacent clutches of early June and middle July and all were hatched. The second egg of the latter clutch was the egg that failed.

Homer × *ring*.—A mating between a male blond ring and a female homer yielded 40 eggs (from October 1898 to March 1900, data not tabulated), 35 of which were tested; 1 hatched, 1 developed to hatching and failed; 1 produced a 13-day embryo, while a fourth egg developed a small embryo. The male was later found to be fully fertile with ring-doves, but infertile with a female Chinese turtle-dove (*Sp. chinensis*). (X 10, X 4)

TABLE 110.

Pair 1.

♂ *C. admista* (Z); 1894 or 1895 (?); weight 368 grams.♀ *St. risoria* (D 2); 7/2/95; weight 163 grams.

A 1. 5/3/96; no development.	♂ L 1. 12/20; hatched; ³ dead 6/28/02.
A 2. 5/5/96; no development.	L 2. 12/22; no record.
♂ B 1. 5/23; hatched; dead at 6 days.	M 1. 1/23/97; no development.
B 2. 5/25; much development (killed by trip ?).	♂ M 2. 1/25/97; (2) hatched; ³ dead 6/28/02.
C 1. 6/19; failed to hatch.	N 1. 2/26; developed 7 day embryo.
C 2. 6/21; failed to hatch.	N 2. 2/28; fully developed; killed.
D 1. 7/1; did not hatch.	♂ O 1. 3/19; hatched; uniform gray.
D 2. 7/3; did not hatch.	O 2. 3/21; (3) no development.
E 1. 7/20; no development.	P 1. 4/17; nearly full development.
E 2. 7/22; no development.	P 2. 4/19; nearly full development.
F 1. 8/2; about 7 day embryo.	Q 1. 5/16; no development.
F 2. 8/4; some development.	Q 2. 5/18; no development.
G 1. 8/24; no development.	R 1. 5/30; no development.
G 2. 8/26; no development.	R 2. 6/1; developed but did not hatch.
H. 9/11; no development.	S 1. 6/20; developed but did not hatch.
I 1. 10/11; no development.	S 2. 6/22; no development.
I 2. 10/13; no development.	♂ T 1. 7/12; (4) hatched; alive 6/29/02.
J 1. 10/31; some development.	T 2. 7/14; hatched; dead at 5 days.
♂ J 2. 11/2; hatched; ¹ dead at 28 days.	U 1. 8/22; no development.
K 1. 11/30; 3 to 5 day embryo.	U 2. 8/23; soft shell, broken. (F 29, A 14)
K 2. 12/2; no development.	

¹ "This bird has only 11 tail feathers."² "White spots on side of head; three white quills in right wing and one in left wing."³ "Has a white face; unlike eyes."

Pair 2.

♂ Common pigeon; color pure white and with a small crest.

♀ *St. risoria* (D 2); 7/2/95.

O 1. 10/26/97)	one developed, broken; other, no record.	B 1. 12/21; some development.
O 2. 10/28/97)		B 2. 12/23; some development.
A 1. 11/10/97; no development.		C 1. 1/12/98; developed, failed.
A 2. 11/12/97; hatched, dead 6 days (feeding ?).		C 2. 1/14/98; hatched. (C 7/30)

The reciprocal of this cross, namely, a male homer and a female ring-dove, was more successful. The result of a mating made 18 months before the beginning of the cross just described is detailed in table 115. From this mating 10 of the 13

eggs tested were hatched. But the homer here used as sire was a (*Hom. 1*) bird whose remarkably high fertility has already been described in Chapter IX. It will here be noted, however, that the life-term of the offspring is quite short and that the young die suddenly without previous signs of illness.

From 34 tested eggs of a female common pigeon of unknown origin but considered a homer, mated to a male *alba-risoria* hybrid, 6 young were hatched, as shown in table 116. It is notable that the 2 young from this cross whose sex was recorded were classed as females (there is no record of autopsy of either of these birds; see below). This case would seem to constitute a violation of the rule that males only arise from family crosses unless the possible hybridization of the female parent be considered of importance. During 1897, when this sire was immature, 20 of the above-mentioned 34 eggs were laid, and only 2 of these showed even the beginnings of development (7 to 10 day embryos).

Later 91 eggs of this same stray common pigeon (*Hom. 4*) were laid while mated to another male F_2 hybrid (*alba-risoria* \times *risoria-alba*, *E 2*). The result is fully given in table 117. Only 11 birds were hatched from this large number of eggs. The seasonal distribution of color in these offspring is of some interest. 3 birds from the early and best part of the season were quite dark ("much brown"); 3 birds from late in the season were of light color, 1 being "light" and 2 "very light." There was 1 bird recorded as a female among these young.

From these two matings of hybrid ring-dove males with a stray female homer (?), it has been noted that both male and female young were apparently obtained; the female parent was, however, a "stray bird," and although a homer in appearance, may have been a hybrid from a cross with at least another domestic variety. The question of greater importance is, as briefly indicated at the beginning of this chapter, were these offspring birds really females? Neither of them seems to have laid eggs. Two of the three copulated as females and accepted males as mates, but during more than 12 months of such mating were positively known to have produced no eggs. The editor is convinced that the author classified at least 2 of these 3 birds on the basis of their sex-behavior (they were obtained at the beginning of his hybridization studies), and that, in the light of later work, it is very questionable whether these birds bore ovaries. The term of life of the offspring of these two matings is not long, and 2 (or 3) of the 17 young were notably deformed.

In the final mating of this series the male is a bigeneric hybrid (*T. orientalis* \times *St. risoria*) and the female is a homer. The very restricted fertility of the pair is made clear by reference to table 118. It is when fertility is very low, as in this case, that the differences between the developmental capacities of various germs are best shown, and here, too, that "seasonal" differences are the more readily detected. The following statement is found concerning the results of this mating:

Male *OS 1* and the female homer again have developing eggs (March 19, 1909). They previously hatched 1 young at the beginning of the season (see record). Here is another proof of greater strength at the start, at the first of the season.

On July 13 (1909), *OS 1* and the homer again have 2 eggs fertilized, but fail to carry out development. These two eggs, laid July 1 and 3, furnish a *good case of weakness of development in the egg*. One developed for 5 to 6 days. The other developed up to making the first puncture of the shell on July 18. The puncture was open for a space of about 3 to

4 mm., but the bird was dead; it had evidently failed to take the next step onward. I opened the shell and found a good-sized bird, with yolk all absorbed except for a remnant that still projected. The down was pale and rather spare; the beak was pale, with a strong black bar.

I have had cases from these same birds and from others in which the young failed to make a puncture, but had developed to the point when the puncture should have and would have been made had the bird been strong enough to go on. Development, then, in these hybrid fertilizations presents numerous evidences of developmental strength in all degrees. (R 16)

Fertilization is of every degree, and results therefore in simple penetration of sperm which fails to make more than an early beginning of development or nothing at all, or it may give stages of cleavage, etc., up to blood-formation, and from this point it may go on and stop after forming an embryo at any point up to hatching; and when hatched, the fate is not yet settled; the bird may be deformed and still live, it may be too weak to develop further, or go on and die at 3, 4, 5, 6, or more days. All along the line we see that development requires energy, and stops or goes wrong for failure in this.

The male jungle-fowls develop more *rapidly* and *longer* than do female jungle-fowls.

Young birds often make failures. Doves reach the highest point at 3 to 4 years. They sometimes sit without laying when *young*, and also when *old*. (WW 1)

TABLE 111.

♂ *C. laticauda*; from dealer 1896; white; 19 feathers in tail; stolen 7, 12, 98.

♀ *St. risoria* (B); 4/21/95; 12 feathers in tail; stolen 7/12, 98.

A 1. 8/25/96; no development.	B 1. 5/9; no development.
A 2. 8/27/96; pricked shell, failed.	B 2. 5/11; no development.
B 1. 9/18; developed; broken.	C 1. 5/31; developed; killed.
B 2. 9/20; developed; broken.	C 2. 6/2; pricked shell, failed, much yolk.
C 1. 10/6; no development.	D 1. 6/22; developed, lost (trip).
C 2. 10/8; no development.	D 2. 6/24; developed, lost (trip).
D 1. 11/15; no development.	E 1. 7/12; no development.
D 2. 11/17; no development.	E 2. 7/14; no development.
E 1. 11/30; no development.	F 1. 7/31; no development.
E 2. 12/2; no development.	F 2. 8/2; no development.
F. 12/21; thin shell.	G 1. 8/13; no development.
G 1. 12/31; probably no development.	G 2. 8/15; no development.
G 2. 1/2; probably no development.	H 1. 8/23; no development.
	H 2. 8/25; no development.
H 1. 2/14/97; probably no development.	I 1. 10/7; developed near to hatching.
H 2. 2/16/97; probably no development.	I 2. 10/9; developed near to hatching.
I 1. 3/12; probably no development.	J 1. 11 1; did not hatch.
I 2. 3/14; probably no development.	J 2. 11 3; did not hatch.
J 1. 3/22; no record.	♂ K 1. 11/15; hatched; white flecks. ²
J 2. 3/24; no record.	K 2. 11/17; no embryo.
K 1. 4/5; no development.	L 1. 12/15; developed only a blood circle.
K 2. 4/7; no development.	L 2. 12/17; no development.
A 1. 4/17; no development.	
A 2. 4/19; hatched; dead ¹ at 3 weeks; brown; 14 feathers in tail.	M 1. 1/16/98; no development.
	M 2. 1/18/98; no development.

(SS 3)

¹ "I can not account for the death of this bird; it was a very large specimen and very thrifty till the day before it died, when it refused to eat; towards night it breathed slowly and with some difficulty. The tail of this hybrid had 14 feathers."

² "K 1 is marked with white, this being speckled in on the crown and occiput, beginning on a line running over the head from eye to eye. On each side the broken white flecks run just over and behind the eyes—a sort of streak of flecks. The rump also is marked with white in an odd way; the patch of white is here median, but at the base of the tail it is extended clear across the body. There are 13 tail feathers; the three middle feathers are brownish gray; the extra feather is thus a middle one." This bird was killed by the editor, before realizing that it bore a tag, on April 5, 1914. It was then more than 16 years of age. "In 1907-8 this bird acquired 3 white tail feathers."

TABLE 112.

♂ *C. gyrans* (T 3); black Japanese tumbler (13 tail feathers).♀ *St. risoria* (L 1); dead 12/20/99.

A 1. 7/23/97; no development.	C 1. 9/26; lost.	♂ E 1. 10/21; hatched.
♂ A 2. 7/25/97; hatched.	C 2. 9/28; lost.	E 2. 10/23; no development.
♂ B 1. 8/25; hatched.	D 1. 10/10; no development.	F 1. 12/13; hatched.
B 2. 8/27; alive at time to hatch.	D 2. 10/12; no development.	♂ F 2. 12/15; hatched.
G 1. 1/20/98; pricked shell; failed.	K 1. 6/4; no development.	O 1. 9/8; no development.
G 2. 1/22/98; hatched.	K 2. 6/6; no development.	O 2. 9/10; no development.
♂ H 1. 2/19; hatched.	♂ L 1. 6/23; hatched.	P 1. 10/1; no development.
H 2. 2/21; alive, immat. opened.	L 2. 6/25; some development.	P 2. 10/3; no development.
I 1. 4/1; hatched.	M 1. 7/24; no development.	Q 1. 11/1; no development.
I 2. 4/3; no development.	M 2. 7/26; no development.	Q 2. 11/3; no development.
♂ {J 1. 5/19} one hatched, other failed.	N 1. 8/18; no development.	R 1. 12/?; slight development.
♂ {J 2. 5/21}	N 2. 8/20; no development.	R 2. 12/?; no development.
S 1. 1/16/99; no development.	W 1. 5/3; no development.	AA 1. 8/12; no development.
S 2. 1/18/99; no development.	W 2. 5/5; no development.	AA 2. 8/14; no development.
T 1. 2/24; no development.	X 1. 6/3; no development.	BB 1. 10/5; no development.
T 2. 2/26; no development.	X 2. 6/5; no development.	BB 2. 10/7; no development.
U 1. 3/26; no development.	Y 1. 6/30; no development.	CC 1. 10/23; no development.
U 2. 3/28; no development.	Y 2. 7/2; no development.	CC 2. 10/25; no development.
V 1. 4/14; no development.	Z 1. 7/22; no development.	DD 1. 11/21; no record.
V 2. 4/16; no development.	Z 2. 7/24; no development.	DD 2. 11/23; no record. (X 1, A 14)

TABLE 113.

♂ *laticauda* × *risoria* hyb. (K 1).♀ *C. gyrans* (T 1); brown tumbler.

A 1. 6/4/98; no development.	E 1. 9/12/98; no development.	I 1. 6/7; hatched (killed, 8 weeks).
A 2. 6/6/98; no development.	E 2. 9/14/98; no development.	I 2. 6/9; hatched (dead, 2 weeks).
B 1. 7/?; no development.	F 1. 10/6; no development.	J 1. 7/19; hatched (no record).
B 2. 7/?; no development.	F 2. 10/8; no development.	J 2. 7/21; no development.
C 1. 7/28; no development.	G 1. 11/4; no development.	K 1. 8/18; no development.
C 2. 7/30; no development.	G 2. 11/6; no development.	K 2. 8/20; no development.
D 1. 8/23; no development.	H 1. 5/30/99; no development.	L 1. 9/5; no development.
D 2. 8/25; no development.	H 2. 6/1/99; no development.	L 2. 9/7; no development.
	M. 9/15; no record; probably no second egg.	(X 3)

TABLE 114.

♂ *C. gyrans* (T 3); black Japanese tumbler (13 tail feathers).♀ *risoria* × *alba* hyb. (XW 2 D 1); dark color.

A 1. 3/22/00} one failed; one hatched; very small; color	I 1. 1/1/01; no development.
A 2. 3/24/00} gray with black.	I 2. 1/3/01; no development.
B 1. 4/24; no development.	J 1. 1/17; no development.
B 2. 4/26; no development.	J 2. 1/19; no development.
C 1. 5/26; no development.	K 1. 2/14} one thin shell; other some development.
♂ C 2. 5/28; hatched; blackish.	K 2. 2/16}
♂ D 1. 7/5; hatched; brownish-black.	L 1. 4/8; probably no development.
D 2. 7/7; no development.	♂ L 2. 4/10; hatched.
E 1. 8/10; no development.	M 1. 5/20} one hatched; dark gray.
E 2. 8/12; hatched.	M 2. 5/22}
♂ F 1. 9/7; hatched.	N 1. 7/7; no development.
♂ F 2. 9/9; hatched.	♂ N 2. 7/9; hatched; (has 13 rectrices, blackish).
G 1. 10/28; no development.	♂ O 1. 8/10; hatched.
♂ G 2. 10/30; hatched; dove gray.	O 2. 8/12; (1) hatched; blackish.
H 1. 12/14; no development.	P 1 and P 2; laid (1901) but no record.
H 2. 12/16; no development.	Q 1 and Q 2; laid (1901) but no record.

TABLE 114 (continued).

P 1. 2/28/02; no development.	V 1. 2/6/03; broken.
P 2. 2/30/02; no development.	V 2. 2/8/03; broken.
Q 1. 4/2; no development.	W 1. 2/27; some development.
Q 2. 4/4; no development.	W 2. 3/1; some development.
♂ { R 1. 5/13 } one hatched; one failed.	X 1. 4/7; probably no development.
R 2. 5/15 }	X 2. 4/9; probably no development.
S 1. 6/26; probably no development.	Y 1. 5/29 } one developed; other, probably no development.
S 2. 6/28; probably no development.	Y 2. 5/31 }
♂ T 1. 7/20; hatched; gray, to brownish gray.	Z 1. 7/5; no record.
T 2. 7/22; some development.	Z 2. 7/7; no record.
♂ U 1. 12/26; hatched; brownish black.	
U 2. 12/28; probably no development.	

(X 1, A 14)

TABLE 115.

♂ *C. tabellaria* (Hom. 1); from fancier Feb. 1897 (2+ years old); killed 1902.♀ *St. risoria* (M 2); 6/20, 96.

- A 1. 3/11/97; hatched.
 A 2. 3/13/97; hatched; dead at 6 days; healthy till day before death.
 B 1. 4/10; did not hatch.
 B 2. 4/12; did not hatch.
 C 1. 4/30; hatched; dead at 14 days; healthy till day of death.
 C 2. 5/2; hatched; dead at 13 days; healthy till day of death.

♀ *St. risoria* (F) given (Hom. 1) on 6/2/97

- ♂ A 1. 6/5; hatched; probably died early.
 ♂ A 2. 6/7; hatched; dead (on journey) at 13 days.
 B 1. 7/15; hatched; probably died early.
 B 2. 7/17; relieved alive 1 day after time to hatch; immature, died.
 C 1. 8/13; hatched; killed (accident).
 C 2. 8/15; did not hatch.
 D. 9/5; hatched; dead at 16 days; uniform pale gray, with a tinge of isabelline above, on edge of scapulars, coverts, etc.

(BB 5)

TABLE 116.

♂ *alba* × *risoria* hyb. (WD 1 H 2); 11/5/96 (light brown).♀ *C. tabellaria* (?) (4); stray bird; considered a homer, but origin unknown.

- J. (1) hatched 1/27/98. gray. stands awkwardly erect; 12 tail feathers.
 K. (2) hatched 2/28/98. light gray. (some brown); 11 rectrices. dead 6/28/02.
 ? ♀ M 1. (3) hatched 4/27/98. strong tinge isabelline (brown). dead 6/30/02.
 ? ♀ N 1. (4) hatched 5/31/98. white. (creamy on neck and breast.)
 O 1. (5) hatched 6/29/98. alive July '99; mated.
 O 2. (6) hatched 7/27/98. developed to hatching; failed.
 P 1. (6) hatched 7/27/98. alive July '99; mated.
 P 2; no development.
 Q 1, etc.; no development.
 Q 2, etc.; no development.

(A 14, X 2)

¹ The long list of earlier eggs, almost all completely infertile, is omitted. These eggs (of 1897) were laid when the sire was perhaps not fully mature. *M 1*, listed here as female, was probably such in behavior only; see table 52, pair 12.—EDITOR.

TABLE 117.

♂ *alba-risoria* × *risoria-alba* (E 2); hatched 10/6/97; alive 10/23/04 (see pl. 25).♀ *C. tabellaria* (?) (4); same as table 116; stray bird (origin unknown).

- H 1. hatched 9/22/99; no other record.
 O 1. hatched (1900), but died early (exposure ?)
 R. (3) hatched 7/27/00; no other record.
 ♀ S 2. hatched 10/2/00. very light; short legs; dead 6/7/01 (no statement on gonads.—ED.)
 ♂ U 1. hatched 11/28/00. dead 12/10/00.
 EE. (1) hatched 8/30/01. very light (almost like ring-dove).
 II. hatched 9/2/02. dead (exposure ?) at 16 days.
 JJ 2. (2) hatched 10/26/02. light. leg broken, killed; sex ? 9/26/03.
 LL. (4) hatched 3/4/03. much brown in first feathers.
 OO 1. (5) hatched 5/31/03. much brown. dead 12/3/04.
 OO 2. (6) hatched 6/1/03. much brown in first feathers.

(A 14, X 2)

¹ The clutches and eggs not recorded here were completely infertile.—EDITOR.

Further breeding of the three sons and the daughter from the first cross was carried out as follows:

Male *D 1* was mated during two years with a blond ring (table 121), and during another two years with a white ring (table 122). It might seem from a comparison of the two records that, although there is much infertility throughout, this male was more fertile with one of the parent species (*alba*) than with the other (*risoria*). The known value of *age* in relation to fertility, and the lack of this data for the female *alba*, preclude such a conclusion. It is, however, of considerable interest to note that the offspring of *D 1* and the weaker⁹ of these two species (*alba*) are nearly all females. Only 1 male was found among the 9 young whose sex was ascertained. Two of the young from the mating with the blond ring are shown in pls. 37 and 38; one from the mating with *alba* in pl. 38.

The second male (*alba-risoria-turtur* hybrid *G*) was nearly fully fertile with *risoria*, development failing only in the first and last 2 eggs of the first season, and falling a little short only in the second and third of the 10 eggs of the following season. But when mated to his daughter 5 of their 6 eggs failed to hatch. When a hybrid carrying still a different species was offered very little development was possible, and this was found in the first pair of eggs of the season (table 123).

Two of the young of this trispecific \times *risoria* cross were tested for fertility. These were both males, 1 being light (*B 2*) and 1 dark (*C 2*) in color. *B 2* mated to a pure blond produced (July) 2 eggs unable to hatch, followed by a pair (August) that produced 2 young that lived at least till they had adult plumage. The first of these was a male with the color of a blond ring-dove; the second was similar, but more clearly showed the reddish color of *turtur*, her parental grandmother. The result of the mating of *C 2* with a *humilis-risoria* hybrid, the entrance of a fourth species into this cross, is given in table 124. The two offspring are both females and have the composition: $\frac{1}{16}$ *alba*, $\frac{11}{16}$ *risoria*, $\frac{2}{16}$ *turtur*, $\frac{2}{16}$ *humilis*.

The third (*J 1*) of the tested brothers—from the original cross with *T. turtur*—was mated with the same blond ring previously mated and found fairly fertile with another brother (*G*). Fertility was here much restricted, as may be seen by reference to the bottom row of table 123.

We have thus presented the record of 3 trispecific hybrid brothers back-crossed to a *risoria* female. One of the sisters (*D 2*), a sister from the same clutch as *D 1*, was back-crossed to an *alba* male, and the data are presented in table 125. Three different males were tested with this female (*D 2*), and the several records make clear the low degree of fertility of this female trispecific hybrid. With hybrids related to her the infertility was absolute. With pure *risoria* she was, like her 3 brothers, at least partially fertile.

TABLE 119.

♂ *alba-ris.* \times *ris.-alba* hyb. (*D 2*); 8/27/97; brown (lighter color than mate).

♀ *T. turtur* (*B 1*); 4/29/99; alive July 1903; (darker than mate).

A. 3/22/00; soft shell.	♀ F 1. 5/30; very light, dead 9/19, 04. F 2. 6/1; no development.
B 1. 3/30; thin shell; removed.	♂ G. 7/1; color dark as D 1.
B 2. 4/1; thin shell; broken.	H 1. 8/1; no development.
C 1. 4/9; no record.	H 2. 8/3; died autumn 1900.
C 2. 4/11; no record.	I. 4/23/01; thin shell.
♂ D 1. 4/20; darker than D 2; alive 2/11/05.	♂ J 1. 4/30; dark color, killed 2/4, 05.
♀ D 2. 4/22; light; pale centers to feathers.	J 2. 5/2; no development.
♀ E 1. 5/24; very light; dead 7/24/00.	K 1. 7/9; no development.
E 2. 5/26; from perch, broken.	K 2. 7/11; no development.

(DD 4, C)

⁹ See Chapter XV.

TABLE 120.

♂ trispecific × risoria hyb. (A 1); 4/19/01; 9/4/04; grandson; (lighter than mate).
 ♀ T. turtur (B 1) (same as preceding); grand-dam; (darker than mate).

♂ A 1. 4/13/03.	B 1.	dark more like <i>turtur</i> ; ¹ dead 6/29/04.	14½ mo.
♀ A 2. 4/15/03.	B 2.	light like a blond ring; dead 12/20/03.	8 mo.
♂ B 1. 5/12.	B 3.	dark color.	alive 1904.
♂ B 2. 5/14.	B 4.	dark color.	escaped 6/1/05.
C 1. 6/12.	} some development in one, none in other.		D. 7/7; broken.
C 2. 6/14.			
E 1. 7/21.	B 5.	dark; no other record.	
♀ E 2. 7/23.	B 6.	light, trace of red.	dead 5/24/06.
¹ "These young are ½ <i>turtur</i> , ¼ <i>alba</i> , ¼ <i>risoria</i> ."			(DD 6, C).

TABLE 121.

♂ *alba-ris.* × *ris.-alba* × *turtur* hyb. (D 1); 4/20/00; darker hybrid.
 ♀ *St. risoria* (7); 1900.

♂ A 1. 4/19/01; complexion pale, as in <i>risoria</i> (see pl. 37); dead 9/4/04.		
A 2. 4/21/01; (weak, relieved); dead 5/7/01.		
B. 5/22; no development	C 1. 6/2; no development.	D 1. 7/14; no record.
	C 2. 6/4; no development.	D 2. 7/16; no record.
♀ E 1. 8/3; complexion strongly like <i>turtur</i> ; blind eye; killed (pl. 38).		
♂ E 2. 8/5; complexion lighter, more like <i>risoria</i> ; dead 3/5/04.		
F 1. 11/3; some development.		
F 2. 11/5; some development.		
♂ G 1. 12/12; <i>risoria</i> -like; no trace of neck spots in first plumage; dead 3/26/04.		
G 2. 12/14; developed only a circle of blood.		
H 1. 1/19/02; some development.		
♂ H 2. 1/21/02; <i>risoria</i> -like (see pl. 38); dead 4/26/04.		
I 1. 3/1; developed nearly to hatching.		♀ J 1. 4/5; color pale <i>risoria</i> ; dead 11/24/02.
I 2. 3/3; developed a few days.		J 2. 4/7; no development.
K 1. 5/7; some development.	L. 6/27; nearly hatched.	M 1. 7/18; pricked shell.
K 2. 5/9; no development.		M 2. 7/20; nearly hatched.
N 1. 8/11; trace of development.		O 1. 9/30; did not hatch.
N 2. 8/13; some development.		♀ O 2. 10/2; <i>risoria</i> -like; dead 1/6/03.
		(DD 3, C)

TABLE 122.

♂ trispecific (D 1); 4/20/00 (table 119); darker hybrid.
 ♀ *St. alba* (O); 1902.

♀ A 1. 4/8/03.	complexion dusky; more like <i>turtur</i> ; dead 7/14/03.	3 mo.
A 2. 4/10/03; some development.		
♀ B 1. 5/12.	pricked shell, late; possibly deserted.	
♀ B 2. 5/14.	D 2. color like <i>risoria</i> .	dead 5/17/05.
C 1. 7/10; did not hatch.		
C 2. 7/12.	D 3. color lighter than <i>risoria</i> .	dead (cold) 4/18/04.
D 1. 8/12; not tested.		
D 2. 8/14; not tested.		
♂ E 1. 10/3.	D 4. color dark.	? alive 1/3/05.
♀ E 2. 10/5.	D 5. color light; lighter than <i>risoria</i> .	dead 3/1/04.
F 1. 1/13/04; developed only a light circle of blood.		
F 2. 1/15/04; developed only a light circle of blood.		
♀ G 1. 4/3.	D 6. juvenal medium dark, ad. light.	dead 9/9/05.
♀ G 2. 4/5.	D 7. juvenal medium dark, ad. light.	dead 9/?/05.
♀ H 1. 5/12.	D 8. color light as <i>risoria</i> .	dead 12/26/06.
H 2. 5/14; no record.		
I 1. 6/11; no record.		J 1. 7/23; no development.
I 2. 6/13; imperfect.		♀ J 2. 7/25. D 9. lighter than <i>risoria</i> (see pl. 38); alive 1907.
K 1. 8/28; no test.		L 1. 12/16; juvenal like <i>risoria</i> ; died early (care).
K 2. 8/30; no test.		L 2. 12/18. D 10. juvenal like <i>risoria</i> . died at 10 days (care?).
M. 2/11/05; no development.		(DD 3, C)

TABLE 123.

♂ alba-ris. × turtur hyb. (G) ; 7/1/00; (prob. died Mar. 1910).

♀ St. risoria (6); (1900).

A. 5/14/01; no development.	F 1. 2/14/02; 10 day embryo.
♂ B 1. 8/10; hatched; light; dead 3/9/03.	♀ F 2. 2/16/02; light (fertile).
♂ B 2. 8/12; hatched; light (fertile); dead 4/3/05.	♀ G. 4/12; light; dead 9/4/04.
♂ C 1. 10/23; hatched; dark, dead.	♂ H. 5/14; dark; dead 10/21/05.
♂ C 2. 10/25; dark (fertile); dead 2/3/04.	♂ I. 6/30; dark; dead 9/6/04 (pl. 39).
D 1. 12/14; developed only blood ring.	♀ J 1. 8/11; dark; dead 8/28/03.
D 2. 12/16; developed only blood ring.	♀ J 2. 8/13; hatched.
♀ E 1. 1/8/02; dark, killed.	K. 10/1; dark; dead 2/22/03. (F 18, C)
E 2. 1/10/02; blood ring only.	

The daughter G (4/12/02) of the above mated with her father.

A 1. 5/11/03; nearly hatched.	B 1. 5/1/04
A 2. 5/13/03; developed 7 to 10 days.	B 2. 5/3/04
(Other eggs laid, substituted, during 1903).	one hatched; dead at 1 mo.
	C 1. 6/1; no development.
	C 2. 6/3; no development.

A third ♀, orient-risoria hyb. (7) (8/30/04), was given to this ♂ in 1905.

A 1. 6/6/05; developed few days.	B 1. 7/9; no development.	C 1. 8/23; probably no development.
A 2. 6/8/05; developed few days.	B 2. 7/11; no development.	C 2. 8/25; probably no development.
		(DD 3, DD 16)

♂ alba-ris. × ris.-alba × turtur hyb. (J 1); 4/30/01; killed 2/4/05.

♀ St. risoria (6); (1900).

A 1. 4/18/03; hatched; dark.	C 1. no development.
♀ A 2. 4/20/03; hatched; dark, but lighter than A 1.	C 2. no development.
B 1. 5/24; developed; did not prick shell.	D 1. probably no development.
B 2. 5/26; developed a little.	D 2. probably no development. (DD 6, C)

TABLE 124.

♂ alba-ris. × ris.-alba × tur. × risoria (C 2); 10/25/01; dark.

♀ hum.-ris. × risoria (E 2); 7/23/01; dark.

AA1. 4/26/02; no development. ¹	D 1. 2/24/03; no development.	H 1. 5/25; some development.
AA2. 4/28/02; no development.	D 2. 2/26/03; no development.	H 2. 5/27; some development.
A. 5/23; no record.	E 1. 3/16; no development.	I. 7/2; no record.
♀ {B 1. 7/13} one failed, one ♀ reddish	♀ E 2. 3/18; hatched blond.	J 1. 7/19; no development.
{B 2. 7/15} dark.	F. 4/18; not hatched.	J 2. 7/21; no development.
C 1. 8/10; little development.	G 1. 5/5; no development.	K 1. 8/6; probably no development.
C 2. 8/12; little development.	G 2. 5/7; no development.	K 2. 8/8; probably no development.
		(DD 16)

¹ Eggs AA 1 and AA 2 laid by this female while with a male of composition similar to C 2.—EDITOR.

TABLE 125.

Pair 1.

♂ St. alba (O); hatched 1900.

♀ alba-ris. × ris.-alba × turtur (D 2); 4/22/00.

A. 3/29; thin shell.	C 1. 4/15; no development.	E 1. 5/13; no record.	F 1. 7/10; no development.
B 1. 4/5; lost.	C 2. 4/17; no development.	E 2. 5/15; no record.	F 2. 7/12; no development.
B 2. 4/7; thin shell.	D. 4/29; no development.		G. 7/21; no record.

Pair 2.

This ♀ the following year with a ♂ risoria.

A 1. 4/7/02} one broken; other no	B 1. 7/31	one fully developed embryo;	C 1. 8/23; no record (? no development)
A 2. 4/9/02} record.	B 2. 8/2	other probably no development.	C 2. 8/25; no record (? no development)

The above female (D 2) was further mated to a bird (B 4) who was her half-brother, nephew, etc., (see table 120).—EDITOR.

TABLE 125 (continued.)

Pair 3.

♂ alba-ris. × ris.-alba × tur. ×× ris. ××× turtur (B 4); 5/13/03; (inbred) ¹ half-brother ++.
 ♀ alba-ris. × ris.-alba × turtur (D 2); 4/22/00; half-sister ++.

A 1. 4/12/04; little or no development.	C 1. 7/22; no development.	E 1. 3/27/05; no development.
A 2. 4/14/04; little or no development.	C 2. 7/24; no development.	E 2. 3/29/05; no development.
B 1. 5/23; no development.	D 1. 8/7; no record.	F 1. 4/29; no record.
B 2. 5/25; no development.	D 2. 8/9; no record.	F 2. probably not laid. (DD 3)

Pair 4.

♂ T. turtur × T. orientalis hyb. (T0 5); 6/6/04; alive 6/15/15; 11 + yr.
 ♀ alba × risoria (580); 4/29/14; alive 6/15/15; 1 + yr.

B 1. 5/11/15; hatched; dark; alive 6/16/15.	C 1. 5/29; hatched; dark; alive 6/16/15.
♀ B 2. 5/13/15; hatched; dark; accident 6/16/15.	C 2. 5/31; hatched; dark; alive 6/16/15.

¹ Escaped 6/1/05.

SEX-RATIO IN CROSSES OF FAMILIES, SUBFAMILIES, AND GENERA.

A summary of the data on the sex-ratio in the three groups of crosses considered in this chapter is given in table 126. It will be seen that first crosses which involve members of different *families* or of different *subfamilies* yield only(?) males. In both of these groups, particularly where one parent is hybrid, an occasional offspring without sex-glands is produced. When individuals belonging merely to different genera—in this case rather closely related genera—are crossed, both male and female young are produced.

There is reason to believe that different species vary in their tendency to produce male and female offspring; and that *St. alba*, for example, is one that can more readily than many others be made to yield a predominance of female offspring. But this form, along with others, has been shown to *change* in this capacity with respect to width of cross, season, overwork, etc. Regardless of what the differences among the various species in initial tendency to produce a given sex may mean, the data of this volume point out at least several of the conditions which act in such a way as most materially to *modify* the actual production of sex.

TABLE 126.—Sex-ratio in family, subfamily, and generic crosses.

Family.				Subfamily.				Genus.			
Species.	♂	♀	No gonad.	Species.	♂	♀	No gonad.	Species.	♂	♀	No gonad.
♂ admista	6	0	..	♂ carolinensis	16	0	1	♂ alba-ris. × ris.-alba	3	3	..
♀ risoria				♀ risoria				♀ turtur			
♂ illyrica	1	0	..	♂ carolinensis	2	0	..	♂ complex hybrid	3	2	..
♀ risoria				♀ alba-ris. × ris.-alba				♀ turtur			
♂ gyraus	7	0	..	♂ Zen. × Z'dura	3	0	1 ¹	♂ trispecific	10	9	..
♀ risoria				♀ risoria				♀ risoria			
♂ laticauda	1	0	..	♂ Zen. × Z'dura	1	0	2	♂ trispecific hyb.	1	8	..
♀ risoria				♀ alba				♀ alba			
♂ orientalis × risoria	1	0	1					♂ complex hybrid	0	2	..
♀ tabellaria								♀ complex hybrid			
♂ gyraus	11	0	..								
♀ risoria-alba											
♂ tabellaria ²	2	0	..								
♀ risoria											
Total	29	0	1	Total	22	0	4	Total	17	24 ³	..

¹ Very minute testes.

² The female common pigeon (*C. tabellaria* ?) of unknown origin (tables 116, 117) which, with a *hybrid* male, hatched 17 young (1♂, 3 ♀♀). is not included in this tabulation.

³ Eight of these were from a mating that gave 1♂ to 8 ♀.

CHAPTER XII.

SEX-LIMITED HEREDITY IN CROSSES INVOLVING BLOND AND WHITE RING-DOVES AND RELATED SPECIES.

As early as 1896 it was found that crosses of blond and white ring-doves involve a sex-limited inheritance of white color and an approach to a similar limitation upon the inheritance of blond color. Soon afterward the reciprocal hybrids from this cross were bred, and male hybrids were back-crossed with both pure white and pure blond. Still later, crosses between whites, or blonds, or their hybrids, with two other species (*St. douraca* and *St. humilis*) of the same genus were found to show a similar association of sex and color. The results of these three series of crosses, together with matings of some of these forms with a fifth species (*Spil. suratensis*), are presented here.

A full tabulation of the data will be given in the usual manner, since it is desirable to furnish an adequate picture of the generally high degree of fertility existing between these closely related species. There are, too, features of the relation of season to fertility and to color, and data upon "overwork" and the order of eggs in the clutch, which can be presented in no other way.¹ The discussion of the data for some of the crosses has been supplied by the editor. The first group of crosses—of blond and white ring-doves—are described by the author. This description was used in the presentation of the subject to a small group of zoologists in 1897.

CROSSES OF BLOND AND WHITE RING-DOVES.

The bird which is the subject of these remarks² belongs to the family Peristeridæ and to the genus *Turtur*. *Turtur risoria* is the name usually applied to it. The genus and species are described by Salvadori (Birds of the British Museum, vol. 21, 1893, p. 415), and in a footnote to the key to the species I find this remark: "It is uncertain to which species the tame dove belongs."

There is a brown variety—it is technically called an isabelline color—and also a white variety or species. One dealer speaks of this latter species as the "white Vienna dove," but on what authority I do not know. I find that authorities disagree on the question whether the white ring-dove belongs to the same species as the isabelline or blond ring.³

¹ It is not intended to schematize these results according to the current Mendelian practice, for the following reasons: (1) The breeding was not all carried out along Mendelian lines. (2) Whitman early convinced himself—before the rediscovery of Mendel's law—that even in these cases the apparent segregation of "white" and "dark" is in reality quite incomplete; the derived whites bear some pigment and are, in a measure, intermediates; the derived blonds are quite plainly intermediate in the *alba* × *risoria* cross (though some apparently are not so in the reciprocal cross). (3) Again, the conclusion drawn by Dr. Whitman from the great extent and variety of his breeding work is that "dominance" and "recessiveness" are matters of degree, and that by appropriate means these may be reversed; this reversal being seen in such characters as fertility, color, and sex. Of course, we already have the Mendelian ratios as facts, and there is no doubt concerning their existence and common exhibition. But the present work is concerned chiefly with "facts about the facts," and bears upon the interpretation of the basis of heredity. The facts of Mendelism have encouraged an assumption of the existence of qualitative differences as the basis of contrasting characters; some "facts about the facts" led the author to conclude that such differences are really quantitative in nature, and that not gaps, but bridges, lie between contrasting characters.—EDITOR.

² Part of a stenographic report of a lecture delivered before the Zoological Club of the University of Chicago, October 13, 1897. (The copy had been somewhat revised and corrected by the author; references to the birds which were demonstrated during the lecture have been adapted for this work by the editor.)

³ Later Professor Whitman recognized these as distinct species, and treated them as *Streptopelia*, which he considered (partly after Salvadori) as of generic rank. See Chapter XV.—EDITOR.

There are certainly very clear differences between them. For example, in the young bird of the darker species there is a rich supply of "down," the bird being well covered with it. This down has a characteristic appearance, being here rather coarser and shorter than in the domestic pigeon. In the young of the white bird there is scarcely any down; at first sight they seem almost perfectly naked, and are in this respect very distinct from blond rings and from all other related species. The eggs of the white variety are on the average a little smaller, and the species itself is a little smaller than the blond ring. The white variety weighs a little less, and is a little more delicate in all its characters. It is certainly not as strong a species as the dark or blond ring, but the general behavior of the two forms agrees very closely; there is a mark on the neck of the white bird which also reveals a close affinity. At first sight the white bird seems to lack the very prominent black collar of the blond birds, but on closer examination the feathers of the region of the collar are found to have a slightly yellowish tinge. There is no doubt about its having the mark or imprint of the "ring" or collar.

I began my experiments in crossing by making the reciprocal crosses. In one case a white male was mated with a brown female; in the other, a brown male was used with a white female. From this last cross I obtained during the first summer some 15 birds, all of which were of the dark color. There was, however, a difference in depth of color among these offspring. Some were light brown, while others were dark, darker even than the dark parent. In the first cross, where a white male with a brown female were used, something less than half the birds were white; the rest of them were light isabelline.

The results of the second year's work with these first-generation hybrids were as follows: Three pairs were mated. The males were all of the light color (one shown in pl. 25), all having been derived from a pair in which the male was white and the female brown (σ *alba* \times φ *risoria*). The females were from the other family, where the father was brown (φ *risoria* \times φ *alba*), and most of these females were of the darker color. One pair I gave to Dr. Watase, who kept an account of the results. He obtained 10 young during the summer. In one case, I believe, an egg was broken before the young hatched, and he was unable to tell what the color would be. Of the others which he succeeded in raising, 5 were white and 5 of the darker color.

From my own summer's work with 3 pairs of parents I have only 1 dark and 1 white bird alive; 2 have died. I have found these species very convenient ones for experimentation, but during the present summer these birds have been used chiefly for taking care of the young of other birds; this has prevented my getting more of their own young from them. The point of chief interest in these results is this: *In all these pairs, every one of the parents being brown, we get quite a large proportion of white young birds. In other words, the white color of the parent bird shows not in the second, but in the third generation.*⁴ (A 1/1)

The results⁵ of the *alba* \times *risoria* cross are given in table 127. There were 5 young which resembled *risoria* and are called "light brown"; 4 young are designated "white." The few white birds whose sex was known were females; the 3 "light brown" birds of known sex were males. The reciprocal cross gave birds of at least two shades of "brown." The darker of these were females (like sire), but 1 female was not of this color; 2 males and a female were of the lighter color (table 128).

Males from the *alba-risoria* cross were mated to females of the *risoria-alba* cross with the result as summarized in table 129 and more fully given in tables

⁴ That is, in the F_2 generation. It is interesting that this feature of Mendelism was noted by Whitman as early as 1897. This had, however, been noted earlier, on a few forms, not only by Mendel, but by Naudin and by Darwin.—EDITOR.

⁵ The statements and summaries from this point, except those marked as quotations, are made by the editor; the data, of course, are those of the author.

130 and 131. It will be seen that brown and white offspring appear in a nearly 3 : 1 ratio (49 to 18) and that all of the white young of known sex (7) were females. Some of the brown birds of known sex (5 to 19) were also females. That the "brown" birds were by no means the equivalent of pure *St. risoria* will be made clear by a reference to pl. 25.

TABLE 127.

<i>♂ St. alba</i> (W); probably alive 1900.		
<i>♀ St. risoria</i> (D 1); 7/15/95.		
B 1. 3/29/96; unhatched.	D 1. 5/29; disturbed.	♀ G. 9/27; white.
B 2. 3/31/96; unhatched.	D 2. 5/31; light brown.	♀ H 1. 11/3; white.
B. 4/21; no test.	E 1. 6/28; white.	♂ H 2. 11/5; light brown.
C. 4/30; white.	♂ E 2. 6/30; light brown.	I. 12/1; no test.
	♂ F 1. 7/31; light brown.	
	F 2. 8/2; light brown.	

(C 7/10)

TABLE 128.

<i>♂ St. risoria</i> (X); (155 grams wt.).		
<i>♀ St. alba</i> (W 2); (151 g. wt.).		
♀ A 1. 4/9/96; dark brown; 172 g.	E 1. 9/4; unhatched.	
♂ A 2. 4/11/96; light brown; 167 g.	E 2. 9/6; dark.	
♀ B 1. 5/14; dark brown; 177 g.	F 1. 11/26; deserted.	
♂ B 2. 5/16; light brown; 154 g.	F 2. 11/28; deserted.	
♀ C 1. 6/21; dark brown; 157 g.	G 1. 1/4/96; killed by cold.	
♀ C 2. 6/23; dark brown; 153 g.	G 2. 1/6/96; killed by cold.	
♀ D 1. 7/29; dark brown; 142 g.		
♀ D 2. 7/31; light brown; 176 g.		

(XS 5)

TABLE 129.—Color and sex of offspring of *alba-risoria* hybrid males × *risoria-alba* hybrid females.

	No.	Males.	Females.	Doubtful.
Pair I { brown . . .	13	4	1	8
Pair I { white . . .	5	..	1	4
Pair II { brown . . .	16	4	3	9
Pair II { white . . .	7	..	3	4
Pair III { brown . . .	20	6	1	13
Pair III { white . . .	6	.	3	3
Total . . { brown . . .	49	14	5	30
Total . . { white . . .	18	0	7	11

TABLE 130.

Pair 1.

♂ *alba* × *risoria* (WDLF 2); light brown; 8/16/96; 6/28/99.♀ *risoria* × *alba* (XW 2 D 1; dark brown; 8/13/96.

A 1. 5/9/97; not hatched.	F 1. 1/8/98; no development.	K 1. 8/20; brown.
A 2. 5/11/97; record indefinite.	F 2. 1/10/98; brown.	K 2. 8/22; brown.
♂ B 1. 6/11; light brown.	G 1. 2/9; brown. ¹	L 1. 10/5; white.
♀ B 2. 6/13; light brown.	G 2. 2/11; white.	L 2. 10/7; white.
♂ C 1. 7/20; brown.	H 1. 4/24; removed.	M 1. 10/27; hatched.
♂ C 2. 7/22; brown.	H 2. 4/26.	M 2. 10/29; hatched.
♀ D 1. 8/25; white.	I 1. 6/7; brown.	N. 4/9/99; no record.
♂ D 2. 8/27; brown.	I 2. 6/9; brown.	O 1. 4/20; no test.
E 1. 11/24; hatched.	J 1. 7/13; brown.	O 2. 4/22; no test.
E 2. 11/26; hatched.	J 2. 7/15; not hatched.	P 1. 5/27; white. ¹
		P 2. 5/29; brown.

(C 7/13. P 16)

¹ Shades of brown were apparently not distinguished during this year.—Error.

TABLE 130 (continued).

Pair 2.

♂ alba × risoria (WD 1 F 1); light brown; 8/15/96.

♀ risoria × alba (XW 2 C 2); dark brown; 7/7/96.

A 1. 4/20/97; removed.	H 1. 1/8/98; brown. ¹	O 1. 8/27/98; removed.
A 2. 4/22/97; removed.	H 2. 1/10/98; brown.	O 2. 8/29/98; removed.
B 1. 5/15; light brown.	I 1. 3/17; brown (?).	P 1. 10/8 ?; brown.
♀ B 2. 5/17; white.	I 2. 3/19; brown (?).	P 2. 10/10; white.
♀ C 1. 6/17; white.	J 1. 4/9; brown.	Q. 11/12; no test.
C 2. 6/19; brown.	J 2. 4/11; no record.	♂ R 1. 12/2; brown.
♀ D 1. 7/22; brown.	K 1. 5/17/98; white.	♀ R 2. 12/4; white.
♂ D 2. 7/24; brown.	K 2. 5/19/98; brown.	S 1. 3/25/99; removed.
♀ E 1. 8/22; brown.	L 1. 6/16; no test.	S 2. 3/27/99; removed.
♂ E 2. 8/24; brown.	L 2. 6/18; no test.	T 1. 4/15; no record.
♂ F 1. 10/14; light brown.	M 1. 6/26; white.	T 2. 4/17; no record.
♀ F 2. 10/16 ?; light brown.	M 2. 6/28; white.	
G 1. 11/29; no record.	N 1. 8/12; broken.	
G 2. 12/1; no record.	N 2. 8/14; broken.	

(C 7/9, C 7/10)

¹ Shades of brown were apparently not distinguished during this year.—EDITOR.

TABLE 131.

Pair 3.

♂ alba × risoria (WD 1 E 2); light brown; 7/14/96; 8/9/99.

♀ risoria × alba (XW 2 C 1); dark brown; 7/6/96.

♀ A 1. 4/30/97; white.	H 1. 4/2/98; brown.	O 1. 3/15/99; no test.
A 2. 5/2; light brown.	H 2. 4/4/98; white.	O 2. 3/17/99; no test.
♂ B 1. 6/8; light brown.	I 1. 6/8; brown.	P 1. 4/9; no test.
B 2. 6/10; no record.	I 2. 6/10; brown.	P 2. 4/11; no test.
♀ C 1. 7/15; light brown.	J 1. 7/6; brown.	Q 1. 5/2; no test.
♂ C 2. 7/17; light brown.	J 2. 7/8; brown.	Q 2. 5/4; no test.
D. 8/19; unhatched; no second.	K 1. 8/8; brown.	R 1. 5/14; no record.
♀ E 1. 9/19; white.	K 2. 8/10; broken.	R 2. 5/16; no record.
♂ E 2. 9/21; brown (pl. 25).	L 1. 10/6; no test.	S 1. 5/31; white.
♂ F 1. 11/2; light brown.	L 2. 10/8; no test.	♂ S 2. 6/2; brown.
♂ F 2. 11/4; light brown.	M 1. 11/6; brown.	T 1. 7/2; brown.
	M 2. 11/8; brown.	T 2. 7/4; brown.
G 1. 2/17/98; white.	N 1. 12/3; brown.	U 1. 7/29; no record.
G 2. 2/19/98; brown.	♀ N 2. 12/5; white.	U 2. 7/31; no record.

(C 7/8)

TABLE 132.

♂ alba-ris. × ris.-alba hyb. (B 1); 6/8/97; light brown.

♀ St. alba (W); white.

A 1. 7/28/98; no development.	♀ F 1. 5/1/99; brown.	K 1 and K 2, not tested.
A 2. 7/30/98; no development.	F 2. 5/3/99; white.	L 1. 11/1; brown.
B 1. 8/20; brown.	♂ G 1. 6/5; white.	L 2. 11/3; white.
B 2. 8/22; white.	♂ G 2. 6/7; white.	M 1. 3/24/00; white.
C 1 and C 2, not tested.	H 1 and H 2, not tested.	M 2. 3/26/00; failed or white.
D 1. 11/3; one hatched.	I 1. 8/4; white.	N 1 and N 2, not tested.
D 2. 11/5; record uncertain.	I 2. 8/6; white.	O 1. 5/25; failed.
E 1 and E 2, not tested.	J 1. 8/31; deserted.	O 2. 5/27; white.
	J 2. 9/2; deserted.	

(X 5, P 16)

TABLE 133.

♂ alba-ris. × ris.-alba hyb. (C 1); 6/20/97; alive 7/25/04; brown.

♀ St. risoria (G); 10/23/95; alive 7/25/04; brown.

C 1. 11/16/99; brown.	L 1. 8/29/00; brown. ¹	T 1. 6/23/04; white.
C 2. 11/18/99; brown.	L 2. 8/31/00; brown.	T 2. 6/25/04; pale blond.
H 1. 4/26/00; soft shell.	N 1. 3/6/00; white.	
H 2. 4/28/00; white.	N 2. 3/8/00; white.	

(X 7)

¹ It is practically certain that these were brown birds, though the color is not recorded at this point.—EDITOR.

Two of the F_2 hybrid males (of light brown color) were back-crossed with pure *St. alba* (table 132) and with *St. risoria* (table 133). Both white and brown young arose from both of these matings. With *alba* there were 9 white to 3 brown;⁶ with *risoria*, 4 white to 5 brown. The sex from none of the birds from the F_2 hybrid \times *risoria* mating is known; but from the F_2 hybrid \times *alba* mating the only brown bird of known sex was a female, and the 2 known males were of white color.⁷

BLOND RINGS AND BLOND-WHITE HYBRIDS CROSSED WITH JAPANESE RINGS.

The Japanese ring-dove (*St. douraca*) is in most respects not greatly unlike the blond ring (*St. risoria*), but it is darker in color and the complexion of the newly hatched young is decidedly darker. When the female *douraca* is mated to a male *risoria* (table 134) the offspring present two colors; one is nearly as light as *risoria* and the other nearly as dark as *douraca*. The lighter colored (like sire) birds are apparently all females and the darker forms (like dam) all males.

The reciprocal cross gave again birds of two colors and apparently all of the resulting females are of the darker color (like sire). The males, however, may be of light or of dark color. The number of young obtained from this cross was too few to throw much light upon the sex-ratio, or upon the proportions of the various colors.

A *risoria* \times *douraca* hybrid male mated to a blond ring gave (table 135) about 7 light and 5 dark offspring; 2 known males were dark and 1 was light; 3 of the females were light and 1 was dark. Two of the young of this cross—Nos. *F* 1 and *F* 2—were mated and found to be fully fertile; they hatched 2 dark and 1 light colored young. One of these had a malformation of the upper mandible—beak—which in these studies has been very frequently found among birds from *weak* germs, germs of hybrid origin, and from inbreds.

The cross of a *risoria-alba* hybrid with a *douraca* female yielded young which approximate to the colors of the three parent species (table 136, pair 1). But it is interesting to find here that 3 of the 6 young are "white," though white is "recessive" (it is sex-limited) with both *risoria* and *douraca*, and though the offspring here are but one-fourth *alba*.⁸ These 3 white young were all females, as was also a *risoria*-colored member of this fraternity; the two young which were nearly as dark as the mother were males.

The mating *inter se* of 2 pairs of these *risoria-alba* \times *douraca* hybrids is of interest in showing the lack of equivalence of the germs produced by the 2 pairs of brothers and sisters from the same fraternity. Pair I (table 137) produced 3 dark and 4 *white*⁹ young, besides 5 eggs incapable of complete development. Pair II threw no white birds in their total of 10 young. Here, however, 6 young were of the lighter shade of *risoria*, and 4 were nearly as dark as *douraca*. The "develop-

⁶ It is notable that the "brown" birds here arose in each instance from the first egg of the clutch, and that the second egg in each of these same three cases developed into a "white" bird.

⁷ The further breeding of the white and blond rings was later turned over to Dr. R. M. Strong, who has already reported his results (Biol. Bull., vol. 23, 1912, p. 293).

⁸ It is quite probable that the predominance of white offspring here is in part related to the fact that the sire (*B* 1) had *alba* as his mother. Both sire and dam, however, died of tuberculosis soon after these eggs were produced, and probably conditions (weakness) favored the production of females (4♀ to 2♂). From another *strong* pair (3) here were produced 3 males to 2 females. These numbers, of course, are quite small; they are given for the sake of completeness.—EDITOR.

⁹ Here again the "recessive white" appears in half (4 of 7) of the offspring, although these young are only one-fourth *St. alba*.—EDITOR.

mental strength" of these germs is here obviously higher than in those from pair I. In this second pair we get failure to complete the development in only the first clutch, and two "very light colored" birds (no whites) only from the last clutch of the season. It will be noted that pair I produced one more clutch of eggs than did II. From pair I—the "weaker" series—were produced 2 males and 3 females, the sexes being of both colors. From pair II—the "stronger" series—2 males and 2 females are known; the light-colored young are of both sexes. The sex of all the dark birds is unknown.

Besides the association of sex and color in inheritance already noted in this cross, or group of crosses, it may be further remarked that the tables indicate a high degree of fertility, and coincidentally a fairly long term of life of the offspring. Inbreeding (table 137) probably introduced a reduction of both fertility and longevity.

TABLE 134.

Pair 1.

♂ *St. risoria* (5); age unknown.♀ *St. douraca* (O); 12/30/02.

♀ A 1.	7/19/01.....	light, nearly color of <i>risoria</i>	dead 3/11/05.....	44 mo.
♂ A 2.	7/21/01.....	decidedly dark (<i>douraca</i>).....	dead 1/13/04.....	30 mo.
♂ B 1.	4/6/02.....	complexion dark; ad. color pale brownish.....	9/6/04.....	29 mo.
B 2.	4/8/02.....	complexion light; ad. color pale brownish.....		
♀ C 1.	5/12.....	light, color of <i>risoria</i> ; fertile.....		
♂ C 2.	5/14.....	dark like <i>douraca</i> ; fertile.....		
♂ D 1.	6/29.....	complexion dark.....	alive 4/9/03; fertile.....	10+ mo.
♂ D 2.	7/1.....	complexion dark.....	dead 9/22/02 (trip).....	2+ mo.

Pair 2.

♂ *St. douraca*; alive 8/3/03.♀ *St. risoria* (C); alive 8/3/03.

♀ A 1.	4/10/02.....	dark, like reciprocal dark birds.....	dead 11/5/02.....	7 mo.
♂ A 2.	4/12/02.....	dark.....	dead 11/28/02.....	7½ mo.
♀ B 1.	5/13.....	quite dark.....	dead 4/10/04.....	23 mo.
B 2.	5/15.....	quite dark.....		
♀ C 1.	6/24.....	dark color.....	dead 12/28/04.....	30 mo.
C 2.	6/26.....	complexion dark.....		
D.	8/1.....	color ?.....	probably died early.....	
♂ E 1.	10/1.....	nearly as light as <i>risoria</i>	dead 1/24/04.....	16 mo.
E 2.	10/3.....	nearly as light as <i>risoria</i>	dead very young.....	?1 mo.

(P 13, A 11)

TABLE 135.

♂ *risoria-douraca* (A 2); very dark; 7/21/01; 1/13/04; 2 yr. 6 mo.♀ *St. risoria* (from 1901); isabelline; alive 1903; 2+ yr.

♂ A 1.	4/21/02.....	hatched, complexion dark; ad. like <i>risoria</i>	dead 10/20/04.....	2 yr. 6 mo.
♀ A 2.	4/23/02.....	hatched, complexion not as dark as A 1 (fertile) ?.....		
B 1.	5/5.....	hatched, color light.....		
B 2.	5/7.....	hatched, complexion light.....	dead 7/5/02.....	2 mo.
C 1.	7/26;	broken.....		
C 2.	7/28;	hatched, color like <i>risoria</i> (fertile).....		
D.	10/17;	no record.....		
♂ and ♀ E 1.	12/1	one, ♂ dark; other, ♀ light.....	dead 4/22/05.....	2 yr. 5 mo.
E 2.	12/3		dead 5/22/03.....	6 mo.
♂ F 1.	2/22/03.....	hatched, light.....	dead 9/9/03.....	5 yr. 7 mo.
♀ F 2.	2/24/03.....	hatched, dark.....	dead 7/5/05.....	2 yr. 5 mo.
♀ G 1.	7/20	one, ♀ light (fertile); other, dark.....	dead 10/19/04.....	1 yr. 3 mo.
G 2.	7/22		dead early (?).....	?1 mo.
H 1.	9/12;	broken.....		
H 2.	9/14.....	hatched, complexion dark.....	dead 11/14/04.....	1 yr. 2 mo.

(P 13, A 11)



A. Adult male Chinese red ring-dove, *Streptopelia humilis*. One year old. $\times 0.7$. Hayashi del., May 1901.
B. Juvenal male Chinese red ring, *Streptopelia humilis*. Age 6 to 7 weeks. $\times 0.7$. Hayashi del., July 1901.



A. Juvenal female, *St. humilis* (Th) × *St. risoria* (h). Hybrid (M1). Age 7 weeks. × 0.7. Hayashi del., July 1901.
 B. Adult male, *St. humilis* (Th) × *St. risoria* (h). Hybrid (C2). Hatched July 1, 1900. × 0.6. Hayashi del.
 This bird was mated to his sister and is the sire of the second generation hybrid (D1) shown in adult plumage in plate 23, figure A, and in juvenal plumage in plate 23, figure B. Note that the color is intermediate; the upper and lower margins of the neck-mark show traces of the white present in *St. risoria*.

TABLE 136.

Pair 1.

♂ *Risoria alba* hyb. (B 1); 3/14/08; 1/30/10 (tuberculosis); very light blond color.♀ *St. douraca* (imported) 1908; 5/17, 10 (tuberculosis); darker color.

AA 1. 5/27/09.....RD 1.....dark.

AA 2. 5/29/09.....RD 2.....dark (these eggs laid while mated to a pure *risoria*).

♂ A 1. 6/27/09.....RD 3.....dark (trace lighter than dam).....dead 11/17/12.....41 mo.

♀ A 2. 6/29/09.....RD 4.....white.....11/10/10.....16½ mo.

♀ B 1. 8/10.....RD 5.....light *risoria*.....dead 10/24/10.....14 mo.

♀ B 2. 8/12.....RD 6.....white (fertile).....stolen 7/19/12.....35+ mo.

♂ and ♀ C 1. 10/8 } C 2 (?) RD 7.....♂ dark (fertile).....dead 4/20/12.....30½ mo.

C 2. 10/10 } C 1 (?) RD 8.....♀ white.....dead 9/3/12.....35½ mo.

(P 10, P 12)

Pair 2.

A ♂ *St. risoria*¹ (82) (imp. 1908) was given 2/18/10; alive 7/5/11; blond color.

A 1. 2/27/10; shell weak, broken.

B 1. 4/6; failed to hatch.

A 2. 3/1/10; shell weak, broken.

♀ B 2. 4/8; RD 9; light blond; 7/24, 13.

Pair 3.

Another ♀ *St. douraca* given May, 1910 (untag.; when or whether dead not known).

♀ A 1. 6/1/10.....RD 10.....light blond.....dead 6/4/11.....12 mo.

♀ A 2. 6/3/10.....RD 11.....light blond.....dead 5/24/12.....24 mo.

B 1. 7/17.....RD 12.....light grayish blond.....dead or disappeared before 2/5/11.

♂ B 2. 7/19.....RD 13.....light grayish blond.....killed 10/23/13.....39+ mo.

♂ C 1. 8/26.....RD 14.....light grayish blond.....killed 10/23/13.....38+ mo.

♂ C 2. 8/28.....RD 15.....light grayish blond.....dead 9/18/14.....49 mo.

(P 12, XX 11)

¹ This bird was probably contaminated with *St. alba*, though imported as pure blond.—EDITOR.TABLE 137.—Results of mating *risoria-alba* × *douraca* hybrids inter se.

Pair 1.

♂ *Risoria-alba* × *douraca* hyb. (3); 11/17/12; brother; dark.♀ *Risoria-alba* × *douraca* hyb. (8); 9/3/12; sister; white.A 1. 3/10/10; white; full term embryo.¹

A 2. 3/12/10; white; full term embryo.

♂ and ♀ D 1. 7/23.....RD 3-D.....dark } 5/26/13 ♂.

D 2. 7/25.....RD 3-D.....dark } 3/25/13 ♀.

B 1. 5/20; some development.

♀ E 1. 9/19.....RD 3-E.....white; dead 2/17/11.

B 2. 5/22; some development.

E 2. 9/21; no development.

C 1. 6/10; some development.

♀ F 1. 10/9; dark; dead 11/26/13.

C 2. 6/12; some development.

♂ F 2. 10/11; white; dead 11/16/11.

Pair 2.

♂ *Risoria-alba* × *douraca* hyb. (7); 10/9/09; 4/20/12; brother; very dark.♀ *Risoria-alba* × *douraca* hyb. (6); 8/12/09; 7/19/12; sister; white.

A 1. 3/7/10; developed, failed to prick shell; complexion light.

A 2. 3/9/10; developed, pricked shell, failed; complexion dark.

B 1. 5/12.....RD 7-B.....dark, disappeared before 11/4/13.

♀ B 2. 5/14.....RD 7-B.....lighter.....10/28/11.....17½ mo.

♂ and ♀ C 1. 7/5.....RD 7-C.....dark } one dead 8/7/11.....13 mo.

C 2. 7/7.....RD 7-C.....lighter } one before 11/4/13.....? mo.

♂ D 1. 8/20.....RD 7-D.....lighter.....3/15/13.....31 mo.

D 2. 8/22.....RD 7-D.....dark.....probably died early.

E 1. 10/10.....RD 7-E.....light *risoria*.....11/8/10 (cold).E 2. 10/12.....RD 7-E.....light *risoria*.....11/7/10 (cold).

(F)

¹ This clutch was deserted.

BLOND AND WHITE RINGS CROSSED WITH RED RINGS.

The red ring-dove (*St. humilis*) is a much darker bird than the blond ring. It has a pronounced vinous-reddish cast, and the unfeathered young have a decidedly dark complexion. An adult male and a juvenal male are figured in pl. 21. In

crosses with white and blond rings, the male of these species and a female red ring being used, the male offspring all have the color of the mother; the female offspring all have the color (lighter) of the sire.

A white ring male mated to a red ring (table 138) gave 18 white and 18 dark young. The 18 white birds are all known to have been females. The sex of 11 dark birds is known; all were males. Three matings of *alba-humilis* hybrids indicate (table 148) a very low fertility for these birds. From a mating of one of these females with a *risoria* × *humilis* male, two dark young (spring) and one light *risoria* (summer), but no whites, were produced.

Crosses of blond rings with red rings gave results similar to those obtained from white rings with red rings. A blond ring male mated to the red ring female threw young of two colors—7 dark, 4 blond. The sex of 4 of the dark birds is known; they were all males; the 3 blond birds of known sex were females (table 139).

The reciprocal of this cross also yielded young of two colors, though these colors were apparently by no means as distinct as in the opposite cross. The color records are adequate for the present purpose in very few cases (table 140), and a conclusion can hardly be drawn from them. An adult male of this composition is shown in pl. 22; a female in juvenal plumage also in pl. 22.

The sex was ascertained in 23 young of the *humilis-risoria* cross; there were 11 males and 12 females. But the sexes were not evenly distributed throughout the three yearly periods. Instead, 4 males and 3 females were from 1900, which is the year of longest average life for offspring. In 1901 again 4 males and 3 females were recorded, while from the third year, that of the shortest-lived offspring, 3 males and 6 females were recorded.

TABLE 138.

♂ *St. alba* (O); 1901 ?; 10/10/06; 5 (?) yr.
♀ *St. humilis* (2 r); 8/30/01; 4/?/06.

♂ A 1. 5/30/02. ....dark. ....1/15/05. ....31½ mo.	N 1. 5/10; no record.
♂ A 2. 6/1/02. ....dark. ....alive 1/31/05. ....32 mo.	♂ N 2. 5/12. ....dark. ....8/9/05. ....15 mo.
B 1. 6/29; 14 day embryo.	♂ O 1. 6/24. ....dark. ....8/20/05. ....14 mo.
♀ B 2. 7/1. ....white. ....alive 1/31/05. ....31 mo.	♀ O 2. 6/26; white.
♀ C 1. 7/29. ....white. ....5/1/05. ....33 mo.	P 1. 7/12; dark.
♂ C 2. 7/31. ....dark. ....8/7/05. ....36 mo.	♀ P 2. 7/14. ....white. ....6/22/06. ....23 mo.
♀ D 1. 8/28. ....white. ....aut. 1902. ....3 mo.	♂ Q 1. 8/14. ....dark. ....2/20/05. ....6½ mo.
D 2. no record.	♂ Q 2. 8/16. ....dark. ....4/10/05. ....8 mo.
♂ E 1. 9/29. ....dark. ....2/10/04. ....16½ mo.	♀ R 1. 9/16; white.
♀ E 2. 10/1. ....white. ....10/15/05. ....36½ mo.	R 2. 9/18; dark.
F 1. 3/22/03; no development.	S. 3/21/05; dark; crooked neck (killed).
F 2. 3/24/03; deserted.	T 1. 4/19; no test.
♀ G 1. 4/12; white; failed to hatch.	T 2. 4/21; no test.
G 2. 4/14; dark.	U 1. 5/10; no test.
H 1. 5/14; unhatched.	U 2. 5/12; no test.
♀ H 2. 5/16; white; lived 1 day (lice).	V 1. 6/14 } one dark (lice-killed).
♀ I 1. 6/3. ....white. ....12/?/06. ....39 mo.	V 2. 6/16 }
♀ I 2. 6/5. ....white. ....5/8/05. ....23 mo.	W 1. 7/4 } one dark.
♀ J 1. 7/6; white; lived 1 day.	W 2. 7/6 }
♀ J 2. 7/8; white.	♀ X 1. 8/2. ....white. ....(lice-killed).
K 1. 8/10; no record.	♀ X 2. 8/4. ....white. ....1/1/06. ....5 mo.
K 2. 8/12; no record.	♂ Y 1. 8/23. ....dark. ....5/?/06. ....9 mo.
♀ L 1. 9/13; white.	♀ Y 2. 8/25; white.
♀ L 2. 9/15; white.	♂ Z 1. 10/2. ....dark. ....12/25/06. ....14 mo.
M 1. 4/9/04; dark.	♂ Z 2. 10/4; dark
M 2. 4/11/04; no development.	

(DD 8, A 12)

The hybrids obtained from the blond and red ring crosses were further bred as follows:

A *humilis-risoria* male and another *risoria-humilis* male were mated to female *alba*. The former cross tested fully fertile (table 141); four tests failed with the latter. In all tests elsewhere made (tables 148, 149) these *risoria-humilis* hybrids, like the *alba-humilis* hybrids referred to above, show a very low fertility; or rather they show many germs which fall short of complete development.

The *humilis-risoria* hybrids, particularly the males of the group, seem very much more fertile. This fertility is quite complete with female *alba* (table 141); it is practically the same with female *humilis* (table 142); it is much less so with female *risoria* (table 143) and with female *humilis-risoria* fertility is very low (tables 146, 147). The female *humilis-risoria* were but partially fertile with a

TABLE 139.

Pair 1.

♂ *St. risoria* (1); 1900; 11/27/07.♀ *St. humilis* (3 r) (THI-C 1); 8/2/00; 5/1/03.

♂ A 1. 8/2/01; dark (fertile); 11/27/07.

A 2. 8/4/01; slight development.

B 1. 4/29/02 } weak shells; broken.
B 2. 5/1/02 }

C 1. 5/9.....dark.....5/31/02.

C 2. 5/11.....light.....5/31/02.

D 1. 6/5/02; broken.

D 2. 6/7/02; broken.

♂ E. 7/15.....medium dark.....8/1/04.

F 1. 9/28; killed in nest.

F 2. 9/30; no development.

(DD 8, A 12)

Pair 2.

♂ *St. risoria* (2); 1900.♀ *St. humilis* (THI-C 2); 1900.

A 1. 8/6/01....dark; dead (?) before 4/1/02.....75 mo.

A 2. 8/8/01....dark; dead (?) before 4/1/02.....75 mo.

♀ B 1. 4/22.....light.....11/26/04.....43 mo.

B 2. 4/24; unhatched.

C 1. 6/2; no record.

C 2. 6/4; no record.

D. 7/7; no development.

♂ E 1. 7/26/02....dark.....1/7/06.....41½ mo.

♂ E 2. 7/28/02....dark.....3/5/04 (killed)....19+ mo.

F 1. 8/25; not tested.

F 2. 8/27; not tested.

♀ G 1. 10/11.....light.....10/6/05.....36 mo.

♀ G 2. 10/13; light. (DD 8, A 12)

TABLE 140.

♂ *St. humilis* (THI-3); dead June 1903.♀ *St. risoria* (h. 9); 1899.

♂ B 1. 5/31/00....darker.....7/10/00.....1½ mo.

♀ B 2. 6/2/00....lighter, fertile. 4/5/06.....70 mo.

♂ C 1. 6/18....lighter, fertile. alive 1/7/02.....22 mo.

♂ C 2. 6/20....fertile (pl. 22) 7/4/05.....60½ mo.

♂ D 1. 7/23....*risoria-humilis*, infertile; 7/25/06. 72 mo.

D 2. 7/25; no development.

E 1. 8/5; not hatched.

E 2. 8/7.....died 10 days old (food ?).....½ mo.

♂ F 1. 8/30....fertile.....5/23/05.....57 mo.

♀ F 2. 9/1....dark (fertile) alive 4/2/02.....19 mo.

G 1. 12/19; no development.

G 2. 12/21; no development.

H 1. 1/10/01; no development.

H 2. 1/12/01; no development.

I 1. 2/6.....hatched (care ?) 4/4/01.....2 mo.

I 2. 2/8.....hatched.....alive 4 ? 01.....2 mo.

J 1. 2/25.....hatched.....4/8/01.....1½ mo.

♂ J 2. 2/27.....hatched.....11/16/01 (care).

K 1. 3/27; not hatched.

♂ K 2. 3/29....fertile.....alive 3 1/05...47+ mo.

L 1. 4/28; some development.

♂ L 2. 4/30; (weakly fertile with O 2); killed 3/28 04; 35+ mo.

♀ M 1. 5/29; hatched; 3/14/05; 45½ mo. (see pl. 22).

M 2. 5/31; probably no development.

♀ N. 7/5.....hatched.....9/9/03.....26 mo.

♂ O 1. 8/5.....dark.....2/12/02.....6 mo.

♀ O 2. 8/7; hatched (weakly fertile with L 2); 9/7/05; 49 mo.

P 1. 3/25/02; not hatched.

♂ P 2. 3/27/02....dark¹.....2/3/04.....22 mo.

♀ Q 1. 4/29.....dark.....6/21/04.....26 mo.

♀ Q 2. 4/31.....hatched.....1/8/04.....20½ mo.

♀ R 1. 6/2.....hatched.....6/20/03.....12½ mo.

♂ R 2. 6/4.....hatched.....8/2/03.....14 mo.

♀ S 1. 7/8.....dark.....alive 3 25 03...9+ mo.

♂ S 2. 7/10.....dark.....alive 3 25 03...9+ mo.

♀ T 1. 8/14.....dark.....9 15 03.....13 mo.

T 2. 8/16.....dark.....3 25 03; missing.

♀ U 1. 9/21.....hatched.....1 14 04.....16 mo.

U 2. 9/23.....hatched.....alive 3 25 03...6+ mo.

V 1. 1 9 03 } one hatched, lived 2 weeks; other some

V 2. 1/11/03 } development.

W 1. 3/6; no record.

W 2. 3/8; no record.

(DD 8, DD 10)

¹ The darker and lighter shades were not thus classified during 1902.—EDITOR.

male *risoria* (table 144); more fertile with a male *humilis* (table 145). Two brother-and-sister matings of *humilis-risoria* hybrids are of interest. One pair of hybrids which were themselves hatched from eggs laid toward the extremes of the season (April and August) was very weakly fertile; only one of their eggs hatched in about 18 tests (table 146). The other pair of parents, hatched from eggs (same clutch) laid in June. This pair was much more fertile, hatching 11 young from 34 tests. One of the males of this group (F_2 generation of *humilis* \times *risoria*) is shown in adult plumage and in juvenal plumage in pl. 23. These illustrations will show that there is a greater similarity of the F_2 generation than of the F_1 generation, with the darker species (*St. humilis*). The two dark birds of this fraternity whose sex is known were males; the only light-colored bird whose sex is known was a female.

Is the whole series of developmental stages a series of reversions?¹⁰ If so, then a final stage, which is a case of reversion, must be *arrested development*. The matter is so regarded by Ewart. I think reversions are not arrests, but due to germs of different stamps. Germs of the same bird may be sometimes white, sometimes brown. My experiments in crossing, and the issue of white offspring¹¹ from dark hybrid parents, seem very instructive in this sense.

We do not start with like germs and stop short with one germ, at white for example, and go on with the other to brown. Otherwise the latest stage would be preceded by white; or, if white be the later stage, then it should be preceded by brown, the brown appearing in the first plumage, the white in the second, after the manner of the *geopelias*.¹² In this case it is not a question of supremacy (prepotency)—a struggle for mastery as Ewart suggests—with victory falling now to the ancestors, now to the moderns, but it is a question of *original constitution*. In the case of these *geopelias* the germ develops and at one age gives the ancestral color and a little later it gives the final color. (T 22)

TABLE 141.

Pair 1.

♂ *Humilis-risoria* hyb. (K 2); 3/9/01; reddish isabelline.♀ *St. alba* (O); 9/20/03; white. Purity (?).

♀ A 1. 7/4/02.....	very light pale <i>risoria</i>	dead 10/5/04*.....	27 mo.
♂ A 2. 7/6/02.....	very light pale <i>risoria</i>	dead 11/27/02.....	4½ mo.
♀ B 1. 8/13.....	complexion dark.....	dead 5/23/05.....	33½ mo.
♂ B 2. 8/15.....	complexion dark.....	dead 10/23/02.....	2 mo.
♀ C 1. 2/13/03.....	complexion dark.....	(sick, killed); 4/15/05.....	26 mo.
♂ C 2. 2/15/03.....	complexion dark.....	(sick, killed); 7/21/04.....	17 mo.
D 1. 3/27; not hatched.			
D 2. 3/29.....	light <i>risoria</i>	dead 4/29/03.....	1 mo.
E 1. 5/4; deserted.			
E 2. 5/6; deserted.			
♂ F. 5/15.....	pale <i>risoria</i> , w. flush of red.....	dead 12/10/04.....	19 mo.
G 1. 7/7.....	<i>risoria-humilis</i>	dead 9/26/03.....	2½ mo.
G 2. 7/9.....	light <i>risoria</i>	dead winter 1903-4.....	7 (?) mo.

Pair 2.

♂ *Risoria-humilis* (A 1).♀ *St. alba* (1); (1901). Purity (?).

A 1. 5/12/02 } one small embryo, one pricked shell.

A 2. 5/14/02 }

B 1. 5/22; circle of blood.

B 2. 5/24; no development.

(DD 9)

* This and the two following clutches present an interesting situation as regards longevity and sex on the one hand, and egg of the clutch and sex on the other. Here the *sire* is a *hybrid*, the dam possibly a *hybrid*; the more typical relation of the sexes within the clutch is reversed; the more typical longevity relation is maintained.—EDITOR.

¹⁰ This is the most complete statement I find on the subject of reversion, and it has been thought best to place it here. It was probably written about 1900-1, and apparently as a result of an examination of Ewart's (*The Penguik Experiments*, London, 1899) ideas on reversion.—EDITOR.

¹¹ Something of the author's (earlier) idea of "germ differences" is thus included in the discussion of reversion.—EDITOR.

¹² See Chapter X, Vol. I.—EDITOR.



- A. Adult male F2 hybrid, *St. humilis* \times *St. risoria* (D1). Hatched May 4, 1901; age 8 months. $\times 0.6$. Hayashi del., Jan. 1902. Sire, *St. humilis* \times *risoria* hybrid (C2), shown in color plate 22, figure B. Dam, *St. humilis* \times *risoria* hybrid (C1). The parents were brother and sister. Color a shade darker and size a little smaller than that of parents. Neck-ring rather narrow. Eye-lid pale whitish. Inner circle of iris dusky or hazel; outer one-half or two-thirds dull-brownish orange.
- B. Juvenal male, *St. humilis* \times *St. risoria* F2 hybrid (D1). Age 6 weeks. $\times 0.7$. Hayashi del., June 1901. Same bird as adult above, figure A. This bird agrees with its hybrid parents and its pure grandparents in having lighter juvenal and darker adult plumage. See characters of the adult.

TABLE 142.

♂ *Humilis-risoria* hyb. (D 1); 7/23/00.¹♀ *St. humilis* (THI-B 2); 7/7/00.

A. 5/29/02; no development.	C 1. 8/12; dark complexion, probably died early.
	C 2. 8/14; dark complexion; probably died early.
♂ B 1. 7/9/... 1 R..... like <i>humilis</i> .	D 1. 10/4; dark complexion, dead 11/5/02.
♀ B 2. 7/11/... 1 R..... lighter color.	D 2. 10/6; dark complexion, dead 11/5/02. (DD)

¹ The sire (D 1) was previously used as sire in a mating with his hybrid sister (F 2). Only weak-shelled eggs (1) and one 7-day embryo were produced (DD 9).

TABLE 143.

♂ *Humilis-risoria* hyb. (F 1); 8/30/00; (dark) reddish isabelline.♀ *St. risoria* (4) 1900.

A 1. 4/25/01; some development. ¹	♂ and ♀ K 1. 4/23; color dark; 12/27/04.
A 2. 4/27/01; some development.	K 2. 4/25; color dark; 2/11/04.
B 1. 5/8; did not develop.	L 1. 5/29; did not hatch.
B 2. 5/10; like <i>humilis</i> ; dead 10 days.	♀ L 2. 5/31; dark; 12/25/03.
C. 5/29; 7 day embryo.	♀ M 1. 6/28 } one dark; 6/10/05; other failed.
	♀ M 2. 6/30 }
D 1. 6/6; no development.	♂ N. 8/15; dark; 8/2/04.
D 2. 6/8; no development.	♀ O 1. 9/27; like <i>risoria</i> ; 12/18/02.
E 1. 7/21; no development.	O 2. 9/29; no development.
♀ E 2. 7/23; like <i>humilis</i> ; alive 3/26/03.	♀ P 1. 2/26/03; dark.
♂ F 1. 10/26; like <i>humilis</i> ; 10/5/04.	P 2. 2/28/03; dark; soon died (care).
♂ F 2. 10/28; like <i>humilis</i> ; alive 3/26/03.	Q 1. 4/15; did not hatch.
♂ G 1. 12/17; like <i>humilis</i> ; 10/7/03.	Q 2. 4/17; did not hatch.
♂ G 2. 12/19; like <i>humilis</i> ; killed; ² 4/30/03.	R 1. 5/8; deserted.
H 1. 2/5/02; 7-10 day development.	R 2. 5/10; deserted.
H 2. 2/7/02; developed to hatching.	S 1. 5/23; no record.
I. 3/1; light color; killed; ² 5/3/02.	S 2. 5/25; no record.
♂ J 1. 3/18 } one failed; other ♂ color of sire; alive 3/26/03.	
♂ J 2. 3/20 }	(DD 9)

¹ Poor incubation.² Had weak legs.

TABLE 144.

♂ *St. risoria* (3); 1900; killed 3/14/05; isabelline as light as mate, no red.♀ *Hum.-risoria* hyb. (B 2); 6/2/00; 4/5/06; light hyb., trace reddish.

A. 4/29/01; some development.	K. 6/26; dark (like dam); alive 3/26/03.
B. 5/27; broken.	♀ L 1. 7/26 } one no development.
C. 6/5; developed 4 to 7 day embryo.	L 2. 7/28 } one like <i>risoria</i> ; dead 11/29/03.
♀ D. 7/8/01; light as sire; ¹ dead 3/10/04.	M. 9/1; no record.
E 1. 8/5; no development.	♀ N. 7/25/03; light; like <i>risoria</i> ; 1/10/07.
E 2. 8/7; no development.	Several eggs laid winter and spring, 1904; no record kept.
F 1. 10/31; hatched; died same day.	O 1. 8/12; no record.
F 2. 11/2; trace of development.	O 2. 8/14; no record.
G 1. 2/26/02; developed to hatching.	P 1. 7/29/04; no development.
♀ G 2. 2/28/02; light as sire; dead 8/9/02.	P 2. 7/31/04; like <i>risoria</i> .
H. 4/6/02; no development.	Q. 8/31/04; 4 R-2 L; light, like <i>risoria</i> .
I 1. 5/2; small embryo.	R 1. 1/4/05; 4 R-3 L; dark.
I 2. 5/4; small embryo.	R 2. 1/6/05; some development (nest bad).
J 1. 5/20; little or no development.	
♂ J 2. 5/22; "usual ? hyb. color" (? medium dark);	
alive 3/26/03.	(DD 9)

¹ All young here called "light" or "risoria-like" have a tinge or cast of red of *humilis*. (DD 9)

TABLE 145.

Pair 1.

♂ <i>St. humilis</i> (3) from dealer 1905; color dark.	
♀ <i>Hum. risoria</i> hyb. (C 1); 6/16/99; color lighter than <i>humilis</i> .	
♂ and ♀ A 1. 8/16/05 one (HHR 1—♂); nearly color of dam; dead 10/?/07.	
A 2. 8/18/05 one (HHR 2—♀); nearly color of sire; dead 8/20/08; fertile.	
B 1. 4/12/06; not well incubated.	E 1. 3/14/07; not well incubated.
B 2. 4/14/06; not well incubated.	E 2. 3/16/07; not well incubated.
♀ C 1. 5/21.....HHR 3.	F 1. 3/30.....HHR 6.....interm. of dam and sire.
♂ C 2. 5/23.....HHR 4.....killed 7/10/06.	F 2. 4/1; did not hatch.
D 1. 9/20.....HHR 5.	G 1. 5/1; did not develop.
D 2. 9/22; did not hatch.	G 2. 5/3; did not develop.

Pair 2.

♂ <i>St. humilis</i> (5); 8/15/00; 6/26/04; dark.	
♀ <i>Hum.-risoria</i> hyb. (F 2); 9/1/00; dark.	
A 1. 5/19/02; no development.	E 1. 5/3; some development.
A 2. 5/21/02; no development.	E 2. 5/5; (4 R); dead 12/6/03.
♀ B 1. 7/17 one ♀ (3 R); color of <i>humilis</i> ♀; 11/20/03.	F 1. 7/25; no record.
B 2. 7/19 one some development.	F 2. 7/27; no record.
C 1. 8/18; did not hatch.	G. 9/19; no record.
C 2. 8/20; did not hatch.	H 1. 4/8/04; developed to hatching, failed.
D 1. 4/10/03; did not hatch.	H 2. 4/10/04; developed to hatching, failed.
D 2. 4/12/03; dark complexion; died at once.	(A 12, DD 8, DD 9)

TABLE 146.

♂ <i>Humilis-risoria</i> hyb. (L 2); 4/30/01; brother.	
♀ <i>Humilis-risoria</i> hyb. (O 2); 8/7/01; sister.	
A 1. 5/4/02; some development; deserted.	F 1. 10/2; no development.
A 2. 5/6/02; some development, broken.	F 2. 10/4; pricked shell, failed.
B 1. 5/25; no development.	G 1. 10/26; no record; probably not hatched.
B 2. 5/27; developed to hatching; perhaps relieved too soon.	G 2. 10/28; no record; probably not hatched.
C 1. 7/10; developed near to hatching; died.	H 1. 4/12/03; no record; probably not hatched.
C 2. 7/12; developed few days.	H 2. 4/14/03; no record; probably not hatched.
D 1. 7/31; developed few days.	I 1. 7/7; developed near to hatching, failed.
D 2. 8/2; developed few days.	I 2. 7/9; developed near to hatching, failed.
E 1. 8/21; did not hatch.	J 1. 9/11; some development.
E 2. 8/23; did not hatch.	J 2. 9/13; some development.
	♀ K 1. 10/6 one ♀ (7) hatched dark; other no development.
	K 2. 10/8
	(DD 1, A 12)

TABLE 147.

♂ <i>Humilis-risoria</i> (C 2); 6/18/00; lighter, <i>hum.-ris.</i> hyb. (see pl. 22).	
♀ <i>Humilis-risoria</i> (C 1); 6/16/00; probably like above.	
A 1. 3/21/01; thin, broken; some development.	♀ N 1. 7/17/3....complexion dark; dead 12/3/02.
A 2. 3/23/01; thin shell broken.	N 2. 7/19/3....complexion light; dead 1/?/04.
B 1. 3/30; soft shell.	O 1. 10/12; no record, probably not hatched.
B 2. 4/1; soft shell.	O 2. 10/14; no record, probably not hatched.
C. 4/10; no development.	
♂ D 1. 4/19...1...like <i>humilis</i> ♀; dead 1/3/03 (see pl. 23).	P 1. 3/25/03; developed.
D 2. 4/21; small embryo.	P 2. 3/27/03; developed.
E 1. 5/16; not hatched.	Q. 4/10; no development.
E 2. 5/18; not hatched.	♂ R 1. 4/27...5...dark (with much red); killed 8/15/04.
F 1. 7/23; no development.	R 2. 4/29...5...dark; dead 10/25/03.
F 2. 7/25; no development.	S 1. 5/30...6...dark; dead 1/1/04.
G 1. 8/7 one, 7 to 12 day development; one; 2...like	S 2. 6/1; no development.
G 2. 8/9 <i>humilis</i> , dead few days.	T 1. 7/28; no record, probably no development.
	T 2. 7/30; no record, probably no development.
H. 3/21/02; no test.	U 1. Spring 1904; no record.
I 1. 4/5; small embryo.	U 2. Spring 1904; no record.
♀ I 2. 4/7...2... <i>risoria</i> -like + reddish...12/5/02.	V 1. Spring 1904; no record.
J 1. 4/23; 6 to 10 day embryo.	V 2. Spring 1904; no record.
J 2. 4/25; 6 to 10 day embryo.	W 1. 5/10 one, = 8; died soon; one, probably no
K 1. 5/13...4...complexion dark.	W 2. 5/12 development.
K 2. 5/15; no development.	X 1. 7/21
L. 6/7; developed (disturbed?).	X 2. 7/23 one color of <i>risoria</i> ; dead at 1 day; one failed.
M 1. 7/3 one 1 to 3 day embryo.	Y 1. 8/9; probably no development.
M 2. 7/5 one less developed.	Y 2. 8/11; probably no development.

(DD 9)

TABLE 148.

Pair 1.

♂ *Risoria-humilis* hyb. (E 1); 7/26/02; dark.♀ *Alba-humilis* hyb. ? (C 1); 7/29/02; white.

A 1. 5/11/03; not hatched.	E 1. 5/8/04; no development.
♂ A 2. 5/13/03. .RAH-1. . . .complexion dark.	E 2. 5/10/04; no development.
B 1. 7/8.RAH-2. . . .complexion light.	F 1. 6/22; (?) no development.
B 2. 7/10; no development.	F 2. 6/24; (?) no development.
C 1. 8/8; (?) no development.	G 1. 8/5
C 2. 8/10; (?) no development.	G 2. 8/7} one, some development; other, none.
D 1. 4/4/04	
D 2. 4/6/04} one no development; RAH-3, dark.	

Pair 2.

♂ *Alba-humilis* hyb. (A 2); 9/29/02; dark.♀ *Risoria-humilis* hyb. (B 1); 4/22/01; light.

A 1. 5/1/03; no development.	B 1. 5/24; probably no development.
A 2. 5/3/03; no development.	B 2. 5/26; probably no development.

Pair 3.

♂ *Alba-humilis* hyb. (A 2); 6/1/02; dark.♀ *Alba-humilis* hyb. (B 2); 7/1/02; white.

A 1. 7/9/03; no development.	C 1. 9/12; (?) no development.	
A 2. 7/11/03; no development.	C 2. 9/14; (?) no development.	
B. 7/27; (?) no development.	D 1. 4/7/04; blood circle.	
B. Probably no second egg.	D 2. 4/9/04; no development.	(DD 7, DD 9)

TABLE 149.—Reciprocal crosses of *humilis-risoria* hybrids.

Pair 1.

♂ *Risoria-humilis* hyb. (A 1); 8/2/01; darker, more like *humilis*.♀ *Humilis-risoria* hyb. (N 1); 5/29/01;; 3/15/05; (?) less dark, toward *risoria*.

A 1. 4/28/02; no development.	G 1. 3/27/03; no development.
A 2. 4/30/02; no development.	G 2. 3/29/03; no development.
B 1. 5/11} one (3) complexion dark (soon died); one did	H. 4/7; some development, deserted.
B 2. 5/13} not hatch.	I 1. 9/14; pricked shell, relieved, (killed).
C 1. 6/3} one some development; one no development.	I 2. 9/16; developed to hatching.
C 2. 6/5}	J 1. 4/3/04; apparently no development.
D 1. 6/30; no development.	J 2. 4/5/04; apparently no development.
♂ D 2. 7/2; (3) color of dam.	K 1. 7/5; no record; probably not hatched.
E 1. 8/2; (4) dark complexion; died soon.	K 2. 7/7; no record; probably not hatched.
E 2. 8/4; not hatched.	♀ L 1. 7/28; (8) darker than sire (not fertile 3/17/08).
F 1. 9/28} one developed few days; one no development.	L 2. 7/30; probably no development.
F 2. 9 30}	

Pair 2.

♂ *Risoria-humilis* hyb. (A 1.); same as above.♀ *Humilis-risoria* hyb. (B 2); 6/2/00; 4/5/06.

A. 4/18/05; near <i>risoria</i> ; killed 5/3/05.	C. 5/30; probably not hatched.
B 1. 4/29; not tested.	
B 2. 5/1; not tested.	

Pair 3.

♂ *Humilis-risoria* hyb. (S 2); 7/10/02; color dark.♀ *Risoria-humilis* hyb. (G 2); 10/13/02; color light.

A 1. 11/7/04; color dark; had a defective eye and killed 1/2/05.	
A 2. 11/9/04; did not develop.	(DD 7, DD 9, A 12)

Pair 4.—Reciprocal cross of $\frac{3}{4}$ *humilis*— $\frac{1}{4}$ *risoria* hybrids.♂ *Humilis-risoria* × *humilis* hyb. (B 1); 7/9/02; dark, near *humilis*.♀ *Humilis* × *risoria-humilis* hyb. (B); 7/18/02; 11/20/03; dark, near *humilis*.

C 1. 5/30/03; complexion dark <i>humilis</i> -like; soon killed by lice.	
♂ D 2. 7/11/03; pale gray <i>risoria</i> -like; dead 8/10/03.	(= all of record; A 12)

CROSSES INVOLVING THE SURATE TURTLE-DOVE, AND BLOND, WHITE, AND RED RING-DOVES.

Several of the hybrids whose nature and origin have been discussed in the preceding pages were crossed with other hybrids containing another (dark) species (*Spilopelia suratensis*) of a genus not distantly related. This material may be more appropriately treated here than elsewhere, though the data for the first crosses of *suratensis* are too meager to permit any conclusion as to an association of sex and color in the offspring. There is, however, evidence here to indicate that "white" and "light color" tend to predominate in the season of lowest fertility (weakest germs), and that the late autumn is the period of such lowest fertility. Similarly, there is here further evidence that the very first egg, or clutch, of the season—particularly when this proceeds from quite early in the season—is weaker than the eggs or clutches that succeed it, and that the second eggs of most of the clutches produced by females of pure species have less developmental energy than have the first eggs of the corresponding clutches.

Before proceeding to an examination of the data bearing upon these points it is here appropriate and of interest to note the sex-ratio in these crosses of closely related species. To give a more definite picture of this situation table 156 has been prepared. Only those crosses in which the female was pure, not hybrid, are thus summarized. It will be seen that the proportion of males and females is nearly or quite normal to intra-specific matings, there being 64 males to 59 females. The fact that some of these species are among those most extensively used in the very wide crosses, from which only males arose, makes the sex-ratio noted here of considerable significance. In many of those very wide crosses the blond ring-dove, for example, was used only as female in the pair. It is demonstrated in table 156 that when matings were made of these more closely related species the sex-ratio remained nearly or quite the same, whether the blond ring was used as male or female parent in the cross.

Four species are represented in the final offspring of this group of matings, and 3 species were combined in several different proportions in some offspring. This permitted a study of the fractionation or divisibility of certain of the characters of these species. Full reference to these points is made in Chapter XVII. Illustrations in color of some of these birds may be placed here, however, since they help to make clear some features of the breeding record. The very distinct characteristics of the Surate turtle-dove are displayed in pl. 24.

Crosses of the Surate turtle (see pl. 24) with the blond ring (table 150) and with an *F₂* *risoria* × *alba* hybrid (table 151) show a very high degree of infertility which

TABLE 150.

♂ <i>Sp. suratensis</i> (1); from dealer 9/30/07; alive 5/30/15.					
♀ <i>St. risoria</i> (757); 7/27/13; alive (tubercular) 2/26/15; (10 clutches before K).					
♂ K 1. 8/10/14; <i>hatched</i> ; dead 8/27/14 (cause ?).		L 1. 8/16; infertile.		M 1. 8/26; infertile.	
? ♀ K 2. 8/12/14; <i>hatched</i> ; dead 8/28/14.		L 2. 8/18; 2 to 4 day embryo.		M 2. 8/28; infertile.	
♀ N 1. 9/5; <i>hatched</i> 124. alive 3/1/15.		O 1. 9/14; infertile.		P 1. 9/25; infertile.	
N 2. 9/7; infertile.		O 2. 9/16; infertile.		P 2. 9/27; infertile.	
Q 1. 10/8.	R 1. 10/20.	S 1. 10/30.	T 1. 11/11.	(all infertile.)	
Q 2. 10/10.	R 2. 10/22.	S 2. 11/1.	T 2. 11/13.	(all infertile.)	
? ♀ U 1. 11/26; full term embryo.		V 1. 12/30; infertile.			
? ♂ U 2. 11/28; full term embryo.		V 2. 1/1/15; infertile (dam tubercular, 1/1/15).			
					(O. R.)



Adult Surate turtle-dove, *Spilopelia suratensis*. $\times 0.7$. Hayashi del.

The full dark centers of the feathers, as seen in *Turtur orientalis*, are here replaced by mesial stripes. Three feathers from neck-mark show divided tips, dark basal parts, and white or brown tips.



A. Adult male, *St. alba-risoria* × *St. risoria-alba*. Hybrid (E2 of table 131). From egg of Sept. 21, 1897; alive Oct. 1904. × 0.5. Hayashi del., Feb. 1902. General coloration distinctly lighter than that of the blond ring (see plate 8). The effect of the white ring (*St. alba*) is further seen in the very light quills of the wing plumage, and in the increased white edging to the feathers of neck-mark. This sturdy individual mated with a homer, a Chinese turtle, and with three ring-doves.

B. Adult male ring-dove × Surate turtle-dove. Hybrid (F). Hatched Sept. 25, 1889. × 0.5. Hayashi del. Sire, *St. alba-risoria* × *risoria-alba* (D2, color of blond ring). Dam, *Spilopelia suratensis*. Note reduction (from *suratensis*) of area of neck mark, the divided feather-tips (three separate feathers); also lighter general color and reduced mesial stripes. See neck-mark in plate 34, figure 4.

TABLE 151.

♂ *alba-ris.* × *ris.-alba* *hyb.* (D 2); 7/24/97; (brown).♀ *Sp. suratensis*; prob. imported 1897; dead 7/20/00.

A 1. 4/11/99; no development.	♂ F 1. 9/13/99; hatched (F-O); mated ¹ to 5 ♀'s; alive 2/19/08 (see pl. 25)	
A 2. 4/13/99; no development.	F 2. 9/15/99; no development.	
B 1. 4/26; no development.	G 1. 9/5; no development.	K 1. 12/21; thin shell, broken.
B 2. 4/28; no development.	G 2. 9/7; no development.	K 2. 12/23; no development.
C 1. 6/5; no development.	H 1. 10/19; no development.	L 1. 1/7/00; no development.
C 2. 6/7; no development.	H 2. 10/21; no development.	L 2. 1/9/00; no development.
D 1. 6/28; no development.	I 1. 11/6; no development.	M 1. 2/10; probably not tested.
D 2. 6/30; no development.	I 2. 11/8; no development.	M 2. 2/11; soft shell.
E 1. 8/1; no development.	J 1. 12/1; pricked shell, died.	
E 2. 8/3; no development.	J 2. 12/3; no development.	(DD 4)

¹ The single offspring from the above cross was mated successively with five different females and became the sire of an interesting progeny. This breeding record is detailed in tables 152, 153.

TABLE 152.

♂ *alba-ris.* × *ris.-alba* × *suraten. hyb.* (F-O); 9/13/99; alive 1908; dark (pl. 25).♀ *St. alba*; (1902 ?); white.

A 1. 4/8/03; some development.	
A 2. 4/10/03; hatched; complexion <i> dusky</i> ; dead at 1 day.	
♂ B 1. 5/1.....T 1.....color pale <i>risoria</i> (see pl. 26).	
♀ B 2. 5/3.....T 2.....darker <i>risoria</i> than B 1; pupil central.	
♀ C 1. 6/5.....T 3.....dark as sire; pupil central (nearly).	♀ E 1. 8/22
C 2. 6/7; few days development.	E 2. 8/24} one (♀ T 5) light as <i>risoria</i> ; other failed
♂ D 1. 7/14.....T 4.....nearly dark as sire; fertile.	F 1. 9/29; no development.
D 2. 7/16; no development.	F 2. 10/1; no development.
G 1. 2/18/04; no development.	H 1. 3/28; dark complexion; killed in nest.
G 2. 2/20/04. T 6.....complexion light <i>risoria</i> .	H 2. 3/30; dark complexion; thrown from nest, killed
	(DD)

TABLE 153.

♂ *alba-ris.* × *ris.-alba* × *suraten. hyb.* (F-O) same as above; 127+ mo., dark.♀ *alba-humilis* *hyb.* (E 2); 10/1/02; 10/15/05; 36½ mo.; white.

A 1. 6/3/04; no development.	B 1. 7/2/04; no development.
A 2. 6/5/04; no development.	B 2. 7/4/04; no development.
♀ <i>St. risoria</i> , 1903, given 8/20/04; typical blond ring.	
A 1. 8/24/04	} one, hatched; complexion dark <i>risoria</i> ; dead (lice) at 1 day; other, no development.
A 2. 8/26/04	
♀ <i>St. humilis</i> (4) given 5/27/05; dead 2/?/06.	
A 1. 6/15/05; no development.	B 1. 7/?/05; no development.
A 2. 6/17/05; no development.	B 2. 7/?/05; no development.
♂ C 1. 8/11.....RSH 1.....color of <i>ris.-humilis</i> ♂.	
C 2. 8/13; no development.	
This ♂ refused to accept other ♀'s offered him till ♀ <i>St. alba</i> (from dealer, probably 1905) given Sept. 1906.	
A 1. 9/18/06; no development.	
A 2. 9/20/06; no development.	
♂ B 1. 9/24.....RS-A 1.....pale, very light <i>risoria</i>.....dead 4/10/09.....30½ mo.	
B 2. 9/26; no development.	
♀ C 1. 2/14/07.....RS-A 2..... <i>risoria</i> nearly.....dead 12/22/08.....22 mo.	
C 2. 2/16/07; no development.	
♂ D 1. 3/24.....RS-A 3.....darker than RS-A 2.....dead 6/28/10.....39 mo.	
D 2. 3/26; no record, probably not hatched.	
E 1. 4/26; no development.	F 1. 6/?; no development.
E 2. 4/28; no development.	F 2. 6/?; no development.
G 1. 8/1; hatched, diminutive <i>risoria</i> ; dead (lice) at a day.	
G 2. 8/3; no development.	
H 1. 8/25.....RS-A 3-R.....complexion dark.....dead before 2/5/11.	
H 2. 8/27; no development.	
♂ I 1. 10/10.....RS-A 5.....complexion dark, dead (lice) at 12 days.	
♂ I 2. 10/12.....RS-A 6.....complexion dark, dead (lice) at 12 days.	
J. 2/19/08; no development.	

(DD)

is doubtless partly accounted for by the fact that in each case one parent died at or near the close of the breeding period. From the latter cross a single bird matured. This male (*F-O*), though of general dark color, was a true intermediate to his ring-*Surate* parents in color and color-pattern characteristics, as is well shown in pl. 25. He was mated to 5 different females, as indicated in tables 152 and 153. When 4 to 5 years old and mated to a *St. alba*, half of the eggs produced were hatched; at 7 to 8 years old, with another *alba*, only 7 of 19 eggs were hatched. With an *alba-humilis* hybrid—a group elsewhere noted to be of low fertility—there was no trace of development in any of 4 tests. With *St. risoria* 1 young hatched from 2 tests; and with *St. humilis* 1 young hatched from 6 tests. It is clear therefore, that this bigeneric hybrid did not possess full fertility with 2 of the 3 parental species, nor with a third one related to them.

One of the offspring of the above-described male (*F-O*) and a *St. alba* female is shown in color in pl. 26. Its color is several grades lighter than that of the sire. Some of this fraternity were, however, darker than this individual. There was in this family no limitation of color by sex; there were darker and lighter males, as well as darker and lighter females. The pale-colored male just referred to in the plate was crossed with a *humilis-risoria* hybrid (table 154), which was darker than the mate in color, and with this bird threw several "white" young (5 of 13), in addition to two or three different darker shades of young. One of the darker of these dark offspring is reproduced in pl. 26. This interesting bird is a hybrid of 4 species belonging to two genera.

We may now return to a consideration of other features of the breeding data. The results from the mating of the male (*F-O*) with the pure white rings deserve a further word. This male was $\frac{1}{4}$ *alba*, $\frac{1}{4}$ *risoria*, $\frac{1}{2}$ *suratensis*, and sired 16 young from the two matings with female *St. alba*; there were, however, no white offspring. The tendency toward *suratensis* color in these young is clear in about 9 cases; a tendency toward *risoria* is shown in about 7 individuals. In this case, as previously noted with *orientalis*, *risoria*, and *humilis*, the species *alba*, when used as dam, only slightly modifies the color of the young of the F_1 generation.

In the first mating of this same male with *St. alba* (table 152) it is clear that the late autumn is the period of least developmental capacity for the germs, and that

EXPLANATION OF PLATE 26.

A. Adult male complex hybrid (TH 7). Hatched Apr. 19, 1905. Six-tenths natural size. Hayashi del., July 1906.

Four species are represented in this hybrid: *St. alba* has entered three times ($=5/16$). *St. risoria* has entered three times ($=5/16$). *Spil. suratensis* has entered once ($=2/16$). *St. humilis* has entered once ($=4/16$). The sire is shown in color below, fig. B; neck-mark in pl. 34. The dam was a *St. humilis* \times *St. risoria* hybrid (O 2) of dark color.

The size of TH 7 is about the same as that of *St. risoria* \times *St. humilis* hybrids, or a trifle smaller. The color strongly resembles a male *St. risoria* \times *St. humilis* hybrid, but with a weak *suratensis* mark (mesial stripe), which is about the same as that of the first *risoria* \times *suratensis* hybrid. The mesial stripes of the sire (T 1) are very faint in this bird; this is caused not by a direct effect on the region of the mark, but by a strengthening of the pigmentation as a whole. The neck-mark is now practically that of 14/16 of the ancestry.

B. Adult male *Streptopelia risoria* (1/8) — *Spilopelia suratensis* (1/4) — *St. alba* (5/8) hybrid (T 1). Hatched May 16, 1903. Six-tenths natural size.

Sire, shown in color, pl. 25, fig. B. Dam, *St. alba* (1902).

Note another degree of "lightening" of the *Spil. suratensis* color, through a second ring-dove cross. The area of the neck-mark is further limited, and once more approaches the proportions found in the ring-dove. A slight division of the feather-tip persists.



A. Adult male complex hybrid (TH7). Hatched Apr. 19, 1905. $\times 0.6$. Hayashi del., July 1906.

B. Adult male, *Streptopelia risoria* ($\frac{1}{8}$) \times *Spilopelia suratusensis* ($\frac{1}{4}$) \times *St. alba* ($\frac{5}{8}$). Hybrid (T1). Hatched May 16, 1903. $\times 0.6$.

this period is immediately preceded and followed by a predominance of light-colored offspring; while in both the preceding and succeeding spring-time there is a period in which dark color predominates. In the second mating with *alba*, the very first and last eggs of the two seasons show infertility (3 cases) or light color (1 case). The more infertile period here, however, would seem to be May or June. In this last mating the first egg showed greater developmental capacity in 5 cases, less in none. In the earlier cross with *alba*, 2 cases followed the rule and there were 2 exceptions; both of these latter, however, were found in the *first* clutches of the two seasons embraced by the mating period. The earlier matings of this series—pure *risoria* and *suratensis* females—show first eggs of pairs as more fertile in 3 cases, less fertile in 1 case. Two further illustrations of and no exceptions to this rule are given by another *St. alba* female whose record is placed in table 154.

The bearing of season and fertility upon the dominance of light or dark color may be further noted by reference to the first part of table 154. It will there be

TABLE 154.

♂ *alba*-*ris.* × *ris.*-*alba* × *surat.* × × *alba* *hyb.* (T 1); 5/1/03; pale *risoria* (see pl. 26).

♀ *humilis*-*risoria* *hyb.* (O 2); 8/7/01; 9/7/05; 49 mo.; darker than above.

♂ A 1. 6/21/04....TH 1.....color *dark*; fertile with *risoria* (1 pale, and 1 dark ♂ offspring).

A 2. 6/23/04....TH 2.....*dark*; toward *humilis*.

B 1. 7/10; complexion and down indicated *dark* color like A 1 and A 2; dead (out of nest) at 3 days.

B 2. 7/12; very small—to be *white*! dead (out of nest) at about 1 to 2 days.

C 1. 8/2.....TH 3.....complexion and down *dark*, like *humilis*.

C 2. 8/4; color *white*! dead (out of nest) at about 10 days.

D 1. 8/30; small *white*! died (lice) at 1 day.

D 2. 9/1; larger light grayish brown; toward earlier darker young; dead at 18 days.

E 1. 9/27; no development.

E 2. 9/29.....TH 4.....color *white*!

F 1. 10/31.....TH 5.....*light pale risoria*; dead "autumn 1904."

F 2. 11/2; no development.

G 3/14/05; color to be *white*! dead (thrown from nest) at 1 day.

♂ H 1. 4/4.....TH 6.....*dark*; toward *humilis* and *suratensis* (fertile w. *alba*); 8/14/08.....40 mo.

♂ H 2. 4/6.....TH 7.....*dark*; *suratensis* streaks less strong than TH 6 (see pl. 26); matured (G 8)

♂ TH 6 above=*alba*-*ris.* × *ris.*-*alba* × *surat.* × × *alba* × × × *hum.*-*ris.* (*hyb.*); 4/4/05; 8/14/08; 40 mo.; *dark*.

♀ *St. alba*; from dealer 1906; *white*.

♂ A. 5/15/06....TH 6-A.....color *dark*, near *douraca*¹.....dead 2/12/08.....21 mo.

B 1. 9/5) one developed to hatching, failed; light down, and complexion of *risoria*; one, no development.

B 2. 9/7)

C 1. 4/6/07....TH 6-C.....*risoria*-like, w. trace reddish (of *humilis*); dead 12/6/07.....8 mo.

C 2. 4/8/07; no development.

D 1. 2/5/08....TH 6-D.....*pale light risoria*.....12/8/09.....22 mo.

D 2. 2/7/08; developed to hatching, failed; complexion *light risoria*-like.

E 1. 3/7/08; no development (lack of care of ♂ ? and cold ?).

E 2. 3/9/08; no development (lack of care of ♂ ? and cold ?).

♂ TH 6-A above; 5/15/06; 2/12/08 (tuberculosis); 21 mo.; *dark*.

♀ ♀ *St. alba* (1); from dealer 1906; *white*.

♀ A. 9/15/07....TH 6-A-A....*white*; fertile.....alive 4/14/09.....19+ mo.
(G 8, DD)

¹ Japanese rings and blond rings had access to the nest of this pair. It was at first thought that a *douraca* may have left there the egg that hatched this bird; but this consideration was later overruled.—EDITOR.

seen that in this mating the parents are both "hybrids" and that a predominance of dark color resulted from the "strong germs" of the spring, and a predominance of white or of light color from the "weaker germs" of the late season and "out-season." The period of white and pale color is here clearly seen to be the season of greatest infertility.

A case quite like this, but even more diagrammatic in its representation of the relation of color-dominance to season and fertility, is recorded in table 155. This case was separately transcribed by the author from the breeding record and given the following comment. It seems best to present this comment in quite the original form:

White coming in at end of season:

♂ RS-A3—color dark as a Japanese ring,
 ♀ TH 6-A-A—color white.

These birds in 1908 had the following young:

- | | |
|-------------------------------------|---------------------------------|
| A. hatched 6/5, dark as sire. | C 1. hatched 8/22, white! |
| | C 2. no development. |
| B 1. hatched 7/10, dark as sire. | D 1. laid 9/11, no development. |
| B 2. hatched 7/10, ring-dove color. | D 2. laid 9/13, no development. |

Laid once or twice more during autumn, but no development. The color began with dark, later became blond ring, later, white; still later, no development. (R 16)

The sex-ratio obtained from the several matings of non-hybrid females with males of closely related species, considered in this chapter, is summarized in table 156. It will be noted that the ratio is normal and that few of these young were produced from eggs laid at an abnormally rapid rate. Some of the species involved in these crosses with closely related species, and yielding here a normal or nearly normal sex-ratio, are the same species which have earlier been noted to throw very high proportions of males when mated with very distantly related species.

TABLE 155.

♂ $\frac{1}{2}$ alba- $\frac{1}{2}$ ris.- $\frac{1}{2}$ surat. hyb. (RS-A 3); 3/24/07; 6/28/10; 39 mo.; dark as *douraca*.
 ♀ $\frac{1}{2}$ ris.- $\frac{1}{2}$ surat.- $\frac{1}{2}$ hum. $\frac{1}{2}$ alba (TH 6-A-A) (see note); 9/15/07; white.

- A. 4/11/08; no development (this egg from mating with brother (RS-A 1) of above ♂).
- ♂ A. 5/20/08 . . . RS-TH-A . . . nearly color of sire; dark dead 8/13/08 12 wks.
- ♂ B 1. 6/24 RS-TH-B-r . . . trace lighter than sire; dark dead 9/30/08 14 wks.
- B 2. 6/26 RS-TH-B-l . . . like *risoria*—pale.
- ♂ C 1. 8/6 RS-TH-C . . . white! dead 1/1/10 17 mo.
- C 2. 8/8; no development.
- D 1. 9/11; no development. (Some later eggs; no development.)
- D 2. 9/13; no development.

- E 1. 4/12/09 . . . RS-TH-E . . . color of sire, dark.
- E 2. 4/14/09; developed to hatching, failed; opened, found dead; white.

(DD)

NOTE.—"It is possible that TH 6-A—the sire of TH 6-A-A—is a hybrid between the common ring (*St. risoria*) and the Japanese ring (*St. douraca*). I had Japanese rings (2), and common rings in the yard, and they may have mated and laid an egg in the nest of ♂ TH 6 (mated with a ♀ alba). This possibility I should not think of except that TH 6-A had the color and form of such a hybrid, and his voice was that of such a hybrid—strongly resembling a Japanese ring's voice. Even TH 6-A-A, although white, yet has a voice that strongly reminds of the Japanese ring. Still I have to hold to the above composition." Later Professor Whitman said (G 8): "I now think that this resemblance of voice to that of the Japanese ring comes through *suratensis*. The syllables are the same in number as in *suratensis*—and the quality and rhythm are similar, though plainly distinct."

TABLE 156.—*Sex-ratio from nonhybrid females crossed with related species.*

Cross.	♂	♀	Cross.	♂	♀	Cross.	♂	♀
♂ risoria	10	7	♂ ris.-douraca	3	4	♂ ris.-alba	2	3
♀ douraca			♀ risoria			♀ douraca		
♂ humilis	11	12	♂ hum.-risoria	7	6	♂ hum.-risoria	1	1
♀ risoria			♀ risoria			♀ humilis		
♂ risoria	4	3	♂ alba-ris. hyb ¹ ..	1	0	♂ alba	18 ²	18
♀ humilis			♀ suratensis			♀ humilis		
♂ suratensis	2	3				♂ trispecific hyb. .	7	5
♀ risoria						♀ alba		
Total	27	25	Total	11	10	Total	28	27

¹ This bird is *alba-risoria* × *risoria-alba*.² Color indicates 18 males; 11 were known to be males.

CHAPTER XIII

OTHER PIGEON HYBRIDS AND THE BREEDING OF SEVERAL PURE SPECIES OF DOVES AND PIGEONS.

There remains for presentation the data for a few crosses of pigeons belonging, for the most part, to groups not hitherto considered. It is also desirable to treat here some data upon the breeding, apart from crossing, of pure wild forms (with one exception). Excepting a relatively small amount of data upon hybridization and simple breeding, which it is quite necessary to place in Volume I of these works, all of the author's results in this field are included in this volume and concluded in the present chapter.¹

The materials now to be considered offer further evidence upon many of the topics which have formed the centers of interest throughout the previous pages. Such topics touched upon by these data may be enumerated: (1) the exclusively male offspring of crosses of most widely separated species; (2) the lower percentages of males from less widely separated crosses; (3) relatively large numbers of infertile eggs from the wide crosses; (4) a restricted life-term for many or most of the embryos and offspring of the widest crosses; (5) abnormally sexed individuals from hybrid parents; (6) weaker germs from the end of the season; (7) a case of the reversal of dominance of color at the end of the season; (8) the predominance of males from the first egg of the clutch in crosses; and (9) also in some pure-bred species. Some hitherto unconsidered data on the breeding of certain pure forms, on the incubation period, on the time between the 2 eggs of the clutch, and between different clutches, are also given in the second part of the chapter.

SEVERAL CROSSES OF DOVES.

It is found convenient to treat 8 crosses or kinds of crosses separately.

Senegalensis × *alba*.—These two birds belong to different genera. *Stigmatopelia senegalensis* is a smaller dove than the blond and white rings with which it was crossed. An adult male of this delicate and very distinct species is shown in pl. 27. Two of three Senegal × blond matings proved fully fertile (table 157); the pair that showed a limitation upon fertility produced all of its eggs in *late* summer. The female offspring are notably smaller than the males; and this is apparently true also when the blond ring is used as the female in the cross.

A brother-and-sister mating of these hybrids was largely infertile (table 158), though 3 other males of this fraternity were almost fully fertile when mated to pure *St. risoria* (table 159); and a fourth male proved similarly fertile with *Spil. suratensis* (table 164). The mating with *risoria* yielded (pair 3) from the last egg of the season an abnormally sexed individual. Pair 1 produced 12 eggs; 10 were tested and all were hatched. The 6 eggs laid before July 5 all hatched birds of dark, *risoria*-like color; the bird from the seventh egg (August 1) was "grayish, nearly white"; its clutch-mate was "white"; the ninth egg (September 6) hatched "white"; the

¹ Numerous records of little consequence, of matings of very short duration, and data not full enough to have significance have, of course, not been presented. All matings giving an adequate or significant test of complete infertility have been specially listed in Chapter II. The textual statement of the present chapter was written by the editor.



Adult male Senegal turtle-dove, *Stigmatopelia senegalensis*. Natural size. Hayashi del., Mar. 1908.
The tail is here shown somewhat expanded. The separate bifurcated feather (with tip) is from the neck-mark ; it is nearly of the general body color. Natural size.

young from the tenth and last egg "died early," before the color of its plumage was learned, but the complexion and down seemed nearly like the blond ring. At this point the author writes on the margin of the record—"weakness at end of season"!

Senegalensis × *risoria*.—The offspring of this cross gave evidence of a sex-limited inheritance of color; the "color of the female is a slight shade darker² than the male; the male has rather more of the vinous tinge on the breast. The orange color of the iris is of deeper color in the female than in the male." (K 8) Three pairs of the primary cross, Senegal × blond, showed fair fertility (table 160). Two of the F₁ males tested fully fertile—one with pure *alba* (table 161), the other with pure *risoria*³

TABLE 157.

Pair 1.		Pair 2.		
♂ <i>Stig. senegalensis</i> (1).		♂ <i>Stig. senegalensis</i> (2).		
♀ <i>St. alba</i> ; age unknown.		♀ <i>St. alba</i> (91); age unknown.		
A 1. 7/20/08	} one developed near to hatching; other apparently did not develop.	♂ A 1. 4/15/09... TS-A 3...	157 g.; dead 11/26/11.	
A 2. 7/22/08		♂ A 2. 4/17/09... TS-A 4...	(starved ?); 11/27/09.	
♂ B 1. 8/14.	TS-A 1.	2/29/11; fertile. ¹	♀ B 1. 5/17. TS-A 5...	dead (food ?); 11/29/09.
B 2. 8/16; no development.			B 2. 5/19. TS-A 6...	dead in nest.
C 1. 9/17; developed; deserted.				
C 2. 9/19; developed; deserted.				

(AA 2)

(AA 2)

Pair 3.

♂ <i>Stig. senegalensis</i> (11).	
♀ <i>St. alba</i> ; age unknown.	
♂ A. 4/5/09... TS-A 2	dead (starved) 11/28/09... 8+ mo.
♂ B 1. 6/1... TS-A 7... 143 g.	fertile ² ... dead 9/23/14... 64 mo.
♂ B 2. 6/3... TS-A 8... 135 g.	fertile... disappeared 7/5/11-11/4/13... 25+ mo.
♂ C 1. 8/15... TS-A 9	dead (starved) 11/28/09... 3½ mo.
♀ C 2. 8/17... TS-A 10... 118 g.	fertile... dead 2/5/12... 30 mo.
♂ D 1. 9/1... TS-A 11... 154 g.	fertile... dead 10/9/11... 25 mo.
♀ D 2. 9/3... TS-A 12... 119 g.	dead 8/19/10... 11½ mo.
♂ E. 10/4... TS-A 13... 144 g.	fertile... dead 7/10/11... 21 mo.
♀ F 1. 5/21/10... TS-A 14	dead 1/16/12... 20 mo.
♂ F 2. 5/23/10... TS-A 15	dead 2/13/12... 21 mo.
♀ G 1. 6/15... TS-A 16	dead 2/13/12... 20 mo.
♀ G 2. 6/17... TS-A 17	dead 2/6/12... 19½ mo.

(P 8, K 8)

¹ Weight of ♂ TS-A 1, 149 g.² Fertile with *Sp. suratensis*.

TABLE 158.

♂ seneg.-alba hyb. (11); 9/1/09; 10/9/11; 25 mo.; brother.	
♀ seneg.-alba hyb. (10); 8/17/09; 2/5/11; 30 mo.; sister.	
A 1. 4/30/10; some development; failed (cold ?)	B 1. 5/21; no development. ¹
A 2. 5/2/10; some development; failed (cold ?).	B 2. 5/23; no development.
C 1. 6/11 } one failed; other hatched, 2 TSA 1; juvenal feathers quite dark; dead 11/25/10 to 2/5/11; 77 mo.	
C 2. 6/13 }	
♂ D 1. 7/9... hatched... 2 TSA 2... color same as 2 TSA 1; dead 11/26/11... 16 mo.	
D 2. 7/11; no development.	
E 1. 8/29; no development.	
E 2. 8/31; no development.	

(AA 6)

¹ "Fertility. We see in this pair a lower fertility than when one of the hybrids is mated with a ring-dove. The optimum usually reached about the end of May, and runs through June and July." (AA 6)

² The complexion of the Senegal dove at hatching is perceptibly darker than that of the blond ring; the darker shade of the F₁ female is similar to that of her sire.—EDITOR.

³ From the latter mating 2 birds are still alive at 5 years old; but a much-sought adequate test of their sex has thus far not been obtained. They lay no eggs, fertilize no eggs, and fight almost continually; they may prove to be hermaphrodites.—EDITOR.

TABLE 159.

Pair 1.

♂ seneg.-alba hyb. (TS-A 1); 8/12/08; 2/29/11.

♀ St. risoria; age unknown.

♂A 1.	5/15/09.....	TS-A-R 1.....	144 g.....	dead 8/1/10; dark like <i>risoria</i> .
A 2.	5/17/09.....			dead hatching (injured?); complexion dark.
♂B 1.	7/3.....	TS-A-R 3.....	151 g.....	dead 12/26/10; dark like <i>risoria</i> .
♂B 2.	7/5.....	TS-A-R 4.....	157 g.....	dead 8/19/10; dark like <i>risoria</i> .

C 1. 5/5/10; laid out of nest.

C 2. 5/7/10; laid out of nest.

♂D 1. 6/4.....TS-A-R 5.....killed in experiment 3/18/14; dark like *risoria*.♂D 2. 6/6.....TS-A-R 6.....dead 1/14/11 or 1/27/12; dark like *risoria*.

♂E 1. 8/1.....TS-A-R 10.....dead 12/30/11; grayish, nearly white.

♀E 2. 8/3.....TS-A-R 11.....dead 9/15/10; white.

F 1. 9/6; developed nearly to hatching, died; white.¹

F 2. 9/8.....TS-A-A 17.....died early, complexion and down nearly blond ring. (AA 3)

Pair 2.

♂ seneg.-alba hyb. (TS-A 8); 6/3/09.

♀ St. risoria (139); no data.

A 1. 5/4/10.....TSAR 7.....dead 5/2/11; as dark as *douraca*A 2. 5/6/10.....TSAR 8.....as dark as *risoria*.

♂B 1. 6/16.....TSAR 9.....dead 1/14/11 or 1/27/12; (juvenile) roseate blond.

B 2. 6/18; did not hatch.

♂C 1. 7/15.....TSAR 14.....killed 10/6/13; (juvenile) soft ruddy blond.

♂C 2. 7/17.....TSAR 15.....dead 1/18/14; (juvenile) darker than C 1, more like *senegalensis*.

D 1. 9/2.....TSAR 18.....probably died early.

D 2. 9/4.....TSAR 19.....probably died early. (AA 4)

Pair 3.

♂ seneg. × alba hyb. (13); 10/4/09; 7/10/11; 21 mo.

♀ St. risoria (O).

A 1. 5/26/10 } one hatched = TSAR 9♂; dead 1/14/11; other some development.

A 2. 5/28/10 }

♂B 1. 6/28.....TSAR 12.....dead 1/8/12; ruddy brown.

? ♀B 2. 6/30.....TSAR 13.....(sex ?)².....dead 1/31/12; dark grayish brown. (AA 5)¹ "Weakness at end of season." (AA 3.)² Sex-glands abnormal; a right gland affected with tumor, ovarian-like; but no trace of a left gonad.—EDITOR.

TABLE 160.

Pair 1.

♂ Stig. senegalensis (1).

♀ St. risoria; dead 6/15/09.

♀A 1. 3/2/09.....TS-R 1.....119 g.

C. 5/25.....TS-R 4.....died early.

A 2. 3/4/09; hatched; died early (care).

♂B 1. 4/10.....TS-R 2.....142 g.....dead 2/26/11.....22 mo.

♀B 2. 4/12.....TS-R 3.....134 g.....disappeared 2/1/11 to 11/4/13.....22 to 55 mo.

Pair 2.

♂ Stig. senegalensis (1).

♀ St. risoria (no mark).

Some eggs laid before following:

A 1. 2/4/10.....TS-R 5; died early (care).

♂C 1. 6/5.....TS-R 7.....dead 3/3/13.

A 2. 2/6/10; probably did not hatch.

♂C 2. 6/7.....TS-R 8.....dead 3/25/12.

B 1. 3/9; did not hatch.

♀D 1. 7/20.....TS-R 9.....dead 1/18/12.

B 2. 3/11.....TS-R 6; disappeared 7/5/11 to 11/4/13.

♂ or ♀D 2. 7/22.....TS-R 10.....alive 10/1/14.

Pair 3.

♂ Stig. senegalensis; (no mark).

♀ St. risoria (O); has a yellow eye.

♂A 1. 4/28/09.....TS-R 20.....143 g.

C 1. 7/13; probably did not hatch.

♂A 2. 4/30/09.....TS-R 21.....127 g.

C 2. 7/15; probably did not hatch.

B 1. 6/4; probably did not hatch.

♂D. 8/8.....TS-R 22¹.....131 g.....dead 11/28/11.

B 2. 6/6; probably did not hatch.

(AA 2, K 8)

¹ Has a pale yellow eye; fertile with *St. risoria*.

(table 162). The data for fertility of the Senegal \times blond and white ring crosses, both in the primary cross and in the resulting hybrids, is therefore higher than will be found in the *family* cross next to be considered. It will soon appear that the *sex-ratio* from the two groups of crosses—genera and family—furnishes a parallel to this difference in fertility. Where infertility is greatest, and the cause of this infertility is width of cross, the ratio of males to females is also highest (table 167).

Migratorius \times *risoria* and *alba-risoria* hybrids.—Two crosses of these forms, which are separated by differences of *family* rank, showed a high percentage of infertility; several embryos incapable of hatching were formed; and a notable fraction of the young died very soon after hatching. The 8 offspring which survived were all males (table 165).

The male species concerned in this mating is the now extinct wild American passenger-pigeon. The above-described hybrids, together with the two listed immediately below, are perhaps the only known hybrids of this remarkable species. The male passenger-pigeon is shown in pl. 28, the female in pl. 29, and one of the hybrids from the *migratorius* \times *alba-risoria* \times *risoria-alba* cross is also shown in pl. 30. The intermediate nature of the hybrid becomes clear from an inspection of the illustration. This topic is further discussed in Chapter XVII.

Migratorius \times *alba*.—This record is short, though similar to the preceding. Two males were produced. The very first egg of the series and the last 3 of the season were wholly infertile.

Miscellaneous crosses.—The three crosses listed in table 166 require but little additional discussion. The *damarensis* \times *risoria-alba* cross (pair 1) is a mating of related species, and the fertility seems high and the term of life moderately long. The *chinensis* \times *suratensis* mating (pair 2) is also one between related species of the genus. The fertility record here falls below that of the preceding cross, and the term of life of the offspring is shorter. The *leuconota* \times *livia* cross (pair 3) tells us only that offspring may be had from this cross. The last of these crosses (pair 4 of table 166) supplied more adequate tests and is of greater interest. The genera involved in that cross—*Melopelia* and *Streptopelia*—belong to different subfamilies, and the table indicates again the very high degree of infertility of such crosses. Only three birds were hatched from the 18 or 20 tests; there were produced, more-

TABLE 161.

♂ Senegal.-risoria (TS-R 2); 4/10/09; 2/26/11; 22 mo.

♀ St. alba; age unknown.

A 1. 5/15/10.....TSRA 1.....disappeared 2/5/11 to 11/4/13.

B 1. 7/24.....TSRA 2.....darker than B 2; disappeared 7/5/11 to 11/4/13.

♀ B 2. 7/26.....TSRA 3.....light ruddy blond; dead 5/7/13.

(AA 6)

TABLE 162.

♂ Seneg.-risoria hyb. (22); 8, 8/09; 11/28, 11; son; pale yellow eye.

♀ St. risoria (O); age unknown; dam; yellow eye.

A 1. 4/16/10.....TS-RR 1.....disappeared 7/5/11-11/4/13 (or, died ? ♀ 7/28/13; darker than A 2).

A 2. 4/18/10.....TS-RR 2.....disappeared 7/5/11-11/4/13 (or, is ♂ or ♂ ♀ alive 10/1/14; lighter than A 1).

B 1. 5/29.....TSRR 1.....disappeared 7/5/11-11/4/13 (or, died ? ♀ 7/28/13).

B 2. 5/31.....TSRR 2.....disappeared 7/5/11-11/4, 13 (or, is ♂ or ♂ ♀ alive 10/1/14).

C 1. 6/30.....TSRR 3.....disappeared before 7/5/11.

? ♂ C 2. 7/2.....TS-RR 4.....alive 10/1/14; is a ♂, or hermaphrodite.

D 1. 9/5.....TS-RR 5.....probably died early; darker than D 2.

D 2. 9/7.....TS-RR 6.....probably died early; lighter than D 1.

(AA 7)

over, very few embryos. The single surviving bird was a male; that this bird was an intermediate of the white-winged pigeon and the ring-dove in color and general appearance is made clear by its illustration in color in pl. 30.

The sex-ratio and width of cross.—The sex-ratios from the crosses already treated in this chapter are summarized in table 167⁴. The data for the breeding of the pure forms treated in the second part of this chapter are also placed in the table to facilitate a comparison. When the cross was between *families* the progeny were all males; when between *genera* there were 17 males to 9 females; from matings of individuals of the same species there were 53 males to 53 females. Here the evidence is again quite clear that the proportion of male offspring increases as forms more and more widely separated phylogenetically are chosen for parents.

TABLE 163.

♂ *seneg.-alba* × *risoria* (TS-A-R 3).
♀ *St. risoria*; age unknown.

♂ ♀ A 1. 5/9.....	TSARR 1 ¹	color dark.....	dead 1/28/12; hermaphrodite (?)
♂ A 2. 5/11.....	TSARR 2.....	color lighter than A 1;	dead 4/26/13.
? ♀ B 1. 6/24.....	TSARR 3.....	pale roseate blond.....	stolen 7/19/12.
♀ B 2. 6/26.....	TSARR 4.....	gray blond.....	dead 2/24/12.
C 1. 8/21.....	TSARR 5.....	dark color, remarkably short, thick beak. ²	
C 2. 8/23.....	TSARR 6.....	color of blond ring, remarkably short, thick beak.	

¹ Had two somewhat flattened sex-glands about 8 by 2 or 2½ mm. Each certainly contained ova, though the anterior part of each gland was testicular in appearance, the few observable small ova being scattered through the posterior part only.—EDITOR.

² The birds from C 1 and C 2 probably died early, before 3 mo. old; but this is not certain.—EDITOR.

TABLE 164.

♂ *senegalensis-alba* (7); 6/1/09; 9/23/14; 64 mo.
♀ *Sp. suratensis* (1908).

♀ A 1. 4/12/10;	light blond; neck-mark intermediate; dead 6/28/10.
A 2. 4/14/10;	no development.
♂ B. 6/10;	light ruddy blond, trifle larger than ring (toward dam); (cold); 11/11/10.
♂ C. 7/26;	rather dark; neck-mark, etc., toward dam; dead (cold) 11/14/10.
D 1. 9/22;	hatched, but died early (cold ?).
D 2. 9/24;	hatched, but died early (cold ?).

(AA)

TABLE 165.

Pair 1.

♂ *Ect. migratorius* (IA) 7/28-29/96.
♀ *alba-risoria* × *risoria-alba* (L 2); dead 3/30/98.

A. 1/26/97; broken.	I 1. 6/5} both developed; one pricked shell,
B 1. 3/1; hatched.	I 2. 6/7} but was accidentally crushed.
B 2. 3/3; no development.	J 1. 6/28; developed; died just before hatching.
C 1. 3/13; no development.	J 2. 6/30; developed; died just before hatching.
C 2. 3/15; no development.	K. 7/10; no development.
D 1. 3/27; developed; died before hatching.	L. 8/4; hatched; dead 3 to 4 days.
♂ D 2. 3/29; hatched.	M 1. 8/13; dead; partly hatched.
E 1. 4/9; hatched; died few hours.	♂ M 2. 8/15; hatched.
E 2. 4/11; broken.	N. 9/8; no development.
F 1. 4/18; pricked shell; failed.	O 1. 10/8; probably no development.
♂ F 2. 4/20; hatched.	O 2. 10/8; probably no development.
♂ G 1. 4/30; hatched.	
♂ G 2. 5/2; hatched; dead 11/30/99.	♂ P 1. 3/24/98; hatched; dead at few days.
H 1. 5/10; no development.	♂ P 2. 3/26/98; hatched; dead at few days (food ?).
♂ H 2. 5/12; hatched.	

⁴ Only first crosses are included in this table. One or two of the crosses which yielded very meager data were omitted for convenience in maintaining the form of the table. The single offspring from a *subfamily* cross (1 ♂ : 0 ♀, table 166, pair 4) is also omitted.



Adult male passenger pigeon, *Ectopistes migratorius*. $\times 0.6$. Hayashi del.



Adult female passenger pigeon, *Ectopistes migratorius*. $\times 0.5$. Hayashi del.

TABLE 165 (continued).

Pair 2.		Pair 3.	
♂ <i>Ect. migratorius</i> (3 L); 7/12-13/98.		♂ <i>Ect. migratorius</i> .	
♀ <i>St. risoria</i> .		♀ <i>St. Alba</i> (C 1).	
A 1. 5/10/03; no development.		A 1. 4/4/98; no development.	
A 2. 5/12/03; hatched (with help); dead at 1 day.		♂ A 2. 4/6/98; hatched; dead 2/11/09. ¹	
B 1. 5/22; probably no development.		♂ B 1. 4/15; hatched.	
B 2. 5/24; broken.		B 2. 4/17; no development.	
C 1. 7/5; broken.		C 1. 9/10; no development.	
C 2. 7/7; broken.		C 2. 9/12; no development.	(X8 4)

¹ The length of life of this hybrid—nearly 11 years—is remarkable. Individuals of the mother species usually live 2 to 5 years. *Ectopistes* are long-lived, probably 12 to 20 years. This hybrid, then, was an intermediate in this respect, as well as in many others.—EDITOR.

TABLE 166.

Pair 1.	
♂ <i>St. damarensis</i> ; age unknown.	
♀ <i>risoria-alba</i> hyb.; age (?).	
♂ A 1. 6/15/10.....DM-R 1.....pale blond.....	dead 3/6/12.....20½ mo.
♂ A 2. 6/17/10.....DM-R 2.....pale blond.....	dead 2/28/12.....20½ mo.

Pair 2.	
Sp. <i>chinensis</i> (Tc).	
Sp. <i>suratensis</i> (Tt).	
A 1. 3/14/00; soft shell.	B 1. 5/31; hatched; probably died early.
A 2. 3/16/00; soft shell.	B 2. 6/2; no development.
♂ C 1. 7/4; hatched; dead 10/5/00; cause unknown.	
♀ C 2. 7/6; hatched; dead 9/18/00; cause unknown.	(DD 15)

Pair 3.	
♂ <i>C. leuconota</i> (1); (1910 or earlier); dead 1/?/15.	
♀ <i>C. livia</i> (C-B 6); 6/23/09; alive 1912.	
A 1. 5/?/11; broken.	B 1. about 6/4
A 2. 5/?/11; broken.	B 2. about 6/4 } one hatched (441); died at few weeks.
	(O. R.)

Pair 4.	
♂ <i>M. leucoptera</i> (1 r); 4/22/99; dull dark, white wings (see text-fig. 8, Vol. I).	
♀ <i>alba-ris.</i> × <i>ris.-alba</i> × <i>alba</i> (F 1); 5/1/99; light brown.	
A 1. 4/25/00; imperfect.	B 1. 5/5; no development.
A 2. 4/27/00; imperfect.	B 2. 5/7; no development.
D 1. 6/20; probably no development.	E 1. 8/9; probably no development.
D 2. 6/22; probably no development.	E 2. 8/11; probably no development.
♂ H 1. 3/16/01; hatched; color of down like <i>Melopelia</i> (see pl. 30); 3/5/03.	
H 2. 3/18/01; no development.	
I 1. 4/?; no development.	J 1. 4/23; no development.
I 2. 4/?; no development.	J 2. 4/25; no development.
L 1. 8/8; did not hatch.	M 1. 8/10; probably no development.
L 2. 8/10; hatched; dead at 2 days.	M 2. 8/12; probably no development.
	(A 14,—?)

TABLE 167.—Sex-ratio in family and generic crosses, and in pure-breds.

Family.	♂	♀	Genera.	♂	♀	Species.					
						Same species.		Same species.		Same species.	
♂ <i>Ectopistes</i>	8	0	♂ <i>senegalensis</i>	7	3	♂ <i>risoria</i>	19	21	♂ <i>senegalensis</i> ..	14	11
♀ <i>risoria</i>			♀ <i>risoria</i>			♀ <i>risoria</i>			♀ <i>senegalensis</i>		
♂ <i>Ectopistes</i>	2	0	♂ <i>senegalensis</i>	10	6	♂ <i>chalconotus</i> ..	5	7	♂ <i>suratensis</i> ..	16	14
♀ <i>alba</i>			♀ <i>alba</i>			♀ <i>chalconotus</i>			♀ <i>suratensis</i>		
Total.....	10	0	Total.....	17	9				Total.....	53	53

BREEDING DATA UPON PURE-BRED PIGEONS AND DOVES.

Some data dealing with various features of the breeding of several species of doves and pigeons are here of interest, not only because they permit comparisons between the results from one and the same species when pure-bred and when crossed, but because they supply additional information on the relation of the order of eggs in the clutch to sex, and on some features of the periods of incubation and egg-production.

Spilopelia suratensis.—In tables 168 and 169 the results of two long series of matings of Surate turtle-doves (see pl. 24) are given. Both records show almost uniformly "weak germs" from the first and the last eggs of the season; the two pairs were (unequally) overworked. In general the term of life of the offspring is longer in those birds hatched from the eggs of spring and early summer. The pair recorded in table 169 was much "overworked" in comparison with the previous mating, and it will be noted that the much-overworked series is clearly the series of lowest fertility and of shortest average term of life in the offspring. In this much-overworked series all of the eggs of no *two* successive clutches were able to hatch, *except* in the early part of the season; here (April 22 to June 18), however, *five* successive clutches hatched without a failure.

Stigmatopelia senegalensis.—The records for this species are summarized in table 170. In this species there is indicated a decided tendency to produce males from the first egg of the clutch and females from the second. There were 11 males from the first and 2 from the second egg. There were 9 females from second eggs and only 2 females from first eggs.⁵

⁵ The breeding of *Chamapelia talpiloti* (table 172) and of *Geotrygon* sp. (table 173) furnish little or no data on sex and are of interest only from the standpoint of fertility; 2 pairs (of *talpiloti*) showed all eggs hatching until late fall; the hatches at this season gave very weak and short-lived offspring.—EDITOR.

EXPLANATION OF PLATE 30.

A. Adult male hybrid (H 1) from a white-winged pigeon and a ring-dove hybrid. One-half natural size. Hayashi del., 1901. Hatched April 1, 1901; dead March 5, 1903.

Sire: *Melopelia leucoptera*. Hatched 4/22/01. A bird of dull dark color with the outer flights of wings white.
Dam: *St. alba-risoria* × *risoria-alba* × *alba*; a bird of light-brown color.

B. Adult male passenger-pigeon × ring-dove hybrid. One-half natural size. Hayashi del.

The wing feathers and markings in this hybrid are (June 18, 1905) as follows:

Tertials, 7: Two inner covered by scapulars. Third exposed, has an obscure, half-washed-out chequer on upper web; this about 15 mm. in length; its distal boundary about 14 mm. from tip of feather. Fourth similarly marked. Fifth has same mark vanishing. Sixth exposed part is darker than fifth, but there is no mark; i.e. the "brown" of the inner feathers gradually diminishes and becomes more gray and a little darker. Seventh slightly less brown and a little darker.

Secondaries, 6: Eighth to thirteenth have an elongated chequer on lower web, beginning with a length of about 24 mm. and extending to within 3 or 4 mm. of tip. The spot grows stronger and longer, becoming about 40 mm., and ending obscurely about 5 mm. from tip on outer secondary, namely the thirteenth feather (including tertials).

Primaries, 10: Fourteenth to twenty-third (counting from inner tertial); a chequer seen on three inner primaries, vanishing on the sixteenth feather (third primary).

Primary coverts, 10: Second to seventh marked with a short chequer on the lower (outer) web, the mark running to the very tip of the feather. In the passenger-pigeon these feathers are black, hence chequers arise by reducing the basal portions to gray.

Scapulars: The inner, second longer scapular has a chequer about 20 mm. long on inner half of inner web and reaches to within 12 mm. of the tip of the feather.

In one hybrid of this derivation these marks were somewhat stronger. They correspond to conspicuous marks in the passenger-pigeon and in the mourning-dove.



- A. Adult male hybrid (H1) from a white-winged pigeon and a ring-dove hybrid. $\times 0.5$. Hayashi del., 1901. Hatched Apr. 1, 1901; dead Mar. 5, 1903.
- B. Adult male passenger-pigeon \times ring-dove hybrid. $\times 0.5$. Hayashi del.

Phaps chalcoptera.—A small amount of data for bronze-wing and crested pigeons is of interest in connection with the question of the sex produced by the first and second eggs of the clutch. Both these Australian species lay 2 eggs in a clutch. In the bronze-wing the slender data would indicate (table 171) a decided tendency for the first egg to produce a male and for the second egg to produce a female. It will be noted that the apparent exceptions to be seen in pair 2 (*A 1* and *B 1*) are nevertheless clutches in which the second egg seemed *weaker* than the first; one of these failed to develop and the other yielded a bird of unknown sex that died when a week old.

Fewer still are the data for the crested pigeon (*Ocyphaps lophotes*). The sex of the birds from the 2 eggs of the same clutch was learned in 3 cases; only one sex arose from each of these clutches. (Sh 18/13)

TABLE 168.

♂ *Sp. suratensis*; imported about 5/1/97.♀ *Sp. suratensis*; imported about 5/1/97.

♀ A 1. 5/31/97; killed; 10/16/97; deformed legs.		B. 6/29; lost (trip).	
A 2. 6/2/97; developed but died before hatching.			
♀ C 1.	8/17.....	10/1/98.....	13 mo. 14 da.
♂ C 2.	8/19.....	9/3/98.....	12 mo. 14 da.
D. 9/26; egg lost.			
E 1.	10/14.....	9/2/98.....	11 mo. ? da.
♀ E 2.	10/16.....	10/2/98.....	11 mo. 16 da.
F 1. 11/18; deserted; nearly fully developed embryo.			
F 2. 11/20; deserted; nearly fully developed embryo.			
G 1.	12/6; developed, but young unable to prick shell.	H 1. 12/28; developed, pricked shell, then died.	
G 2.	12/8; developed, but young unable to prick shell.	H 2. 12/30; developed, died without pricking shell.	
(Birds moved, to stop laying).			
<hr/>			
I 1.	3/23/98; deserted.	K. 4/10; thin shell; broken.	
I 2.	3/25/98; deserted, thin shell.		
J 1.	4/1 } one broken; one some development.	L 1. 5/2; developed near to hatching.	
J 2.	4/3 }	L 2. 5/4; no development; thin shell.	
♂ M 1.	6/3.....	10/17/98.....	4 mo. 14 da.
♂ M 2.	6/5.....	10/14/98.....	4 mo. 9 da.
N 1. 7/2; accident; broken.			
N 2.	7/4.....	10/23/98.....	3 mo. 19 da.
♂ O 1.	7/13.....	11/7/98.....	3 mo. 24 da.
♀ O 2.	7/15.....	10/13/98.....	2 mo. 28 da.
♂ P 1.	8/5.....	10/30/98.....	2 mo. 25 da.
♀ P 2.	8/7.....	10/24/98.....	2 mo. 17 da.
♀ Q 1.	9/14.....	10/26/98.....	1 mo. 12 da.
Q 2. 9/16; hatched; apparently died early.			
♀ R 1.	10/23.....	11/19/98.....	27 da.
♀ R 2.	10/25.....	11/23/98.....	29 da.
<hr/>			
♂ A 1.	4/19/99.....	12/1/99.....	7 mo. 12 da.
A 2. 4/21/99; dwarf egg 25 by 19 mm.; no development.			
♀ B 1. 4/29..... hatched.....		alive July 1901.....	
B 2. 5/1; hatched; alive July 1901.		26+ mo.	
♀ C 1.	5/28.....	12/14/99.....	6 mo. 17 da.
♂ C 2.	5/30.....	12/25/99.....	6 mo. 25 da.
♂ D 1.	6/26.....	11/26/99.....	5 mo.
♀ D 2.	6/28.....	12/29/99.....	6 mo. 1 da.
♀ E 1.	7/26.....	11/27/99.....	4 mo. 1 da.
E 2. 7/28; apparently did not hatch.		(C 7/4)	

Streptopelia risoria.—Attention may first be given to features of the record (tables 174 to 176) other than sex and fertility. In these tables⁶ data are given for the time consumed between sets or clutches of eggs in the blond ring-doves. This period is variable; but it is clear that in the season which was later found to be that of "weak germs" there is probably no natural tendency to *shorten* the period. Such a shortening of the period would of course tend toward still further "overwork," which has been found to lead to the weakening of the germ. Rather do the data indicate that in this late autumn and winter period, when the germs are weakest, the birds are reproductively less active; and this corresponds thoroughly with the common experience with doves and pigeons generally.⁷

The interval between the laying of the 2 eggs of the clutch and the period of incubation were in many cases very accurately determined. The period for the former is nearly 40 hours; for the latter the period is variable and is different for the 2 eggs of the clutch, the first egg requiring usually 12 to 24 hours longer than the second. The author has pointed out, however, that the first egg is usually not incubated perfectly during the first 12 to 24 hours; the female sits or stands but

TABLE 169.

♂ *Sp. suratensis* (1); from dealer (9/30/07); (said to have come from Borneo); alive 1915.

♀ *Sp. suratensis* (1); from dealer (9/30/07); dead 1/12/09; 2+ yr.

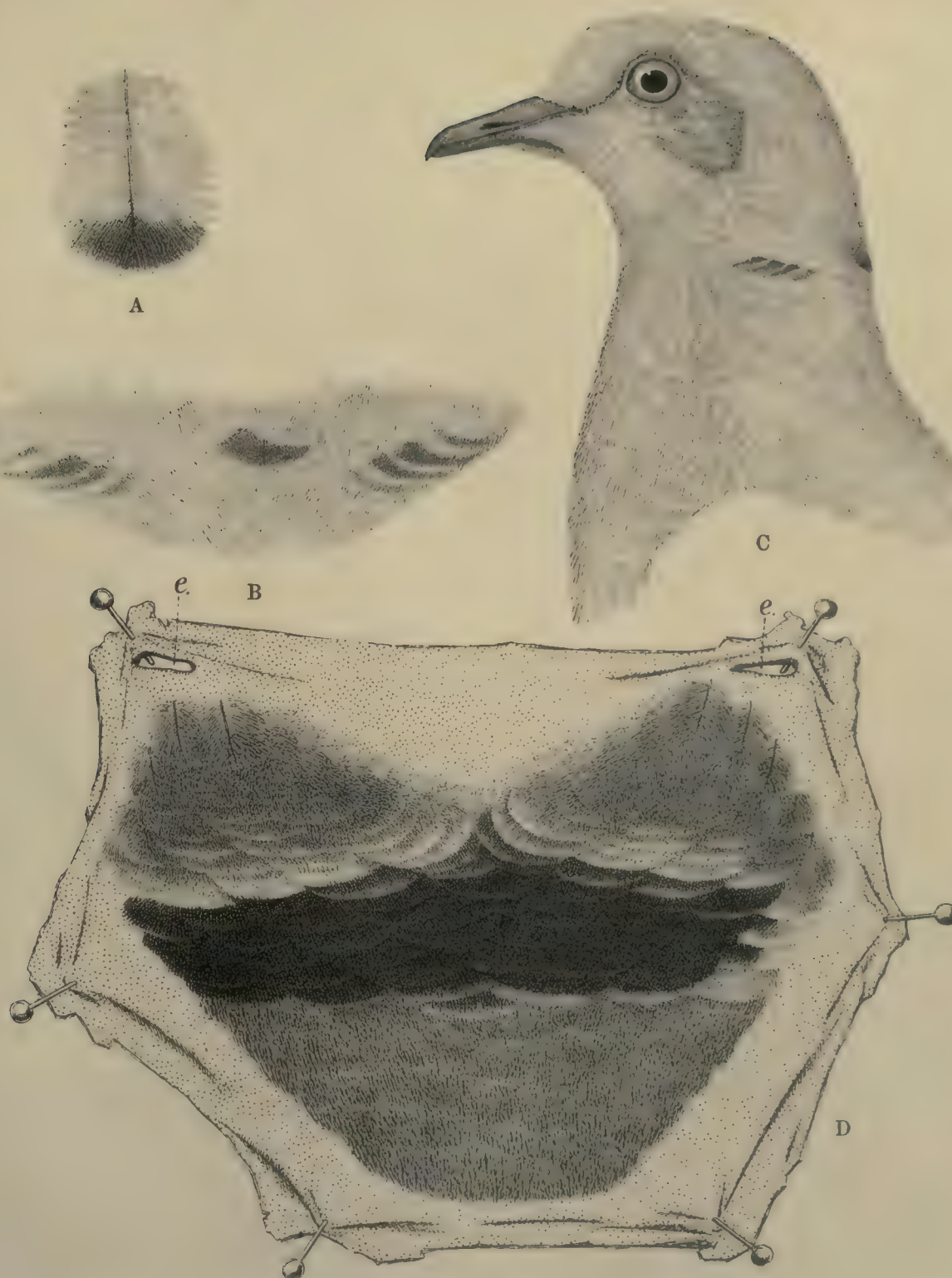
A 1. 10/14/07 } one hatched, neglected; other failed.	P 1. 6/30; deserted.
A 2. 10, 16, 07 }	P 2. 7/2; deserted.
B 1. 11/29; hatched; dead, cold.	Q 1. 7/9; no record.
B 2. 12/1; did not hatch.	Q 2. 7/11; no record.
C 1. 2/25/08; thin shell; no development.	R 1. 7/19.....21.....probably died early.
C 2. 2/27; thin shell; no development.	R 2. 7/21.....22.....probably died early.
D 1. 3/7; hatched; dead at 2 days.	S 1. 7/27; did not hatch.
D 2. 3/9; fully developed; failed.	S 2. 7/29.....23.....probably died very early.
E 1. 3/18; full term embryo; cold.	T 1. 8/4.....24.....dead 9/14/08.
E 2. 3/20; full term embryo; cold.	♂ T 2. 8/6.....25.....dead 9/10/08.
F 1. 3/29; no record.	U 1. 8/14; developed; deserted.
F 2. 3/31; no record.	U 2. 8/16; developed; deserted.
G 1. 4/5.....10.....hatched.	V 1. 8/22.....26.....hatched.
G 2. 4/7; dead at 3 days.	♂ V 2. 8/24.....27.....hatched; dead 9/19/14.
H 1. 4/13; failed.	W 1. 8/31; hatched; died, neglect.
H 2. 4/15; failed.	W 2. 9/2; not hatched.
I 1. 4/22.....11.....hatched.	X 1. 9/7.....28.....hatched.
I 2. 4/24; hatched; dead at 6 days.	X 2. 9/9; no development.
♂ J. 5/2.....12.....hatched; dead 8/5/08.	Y 1. 9/15; failed.
♂ K 1. 5/12.....13.....hatched; dead 10/8/08.	Y 2. 9/17; failed.
K 2. 5/14.....14.....hatched.	Z 1. 10/3; AA 1, 10/11; BB 1, 10/20, not incubated.
♂ L 1. 5/25.....15.....hatched; dead 9/21/08.	Z 2. 10/5; AA 2, 10/13; BB 2, 10/22, not incubated.
♂ L 2. 5/27.....16.....hatched; dead 9/12/08.	CC 1. 11/9.....29.....hatched; died 2/9/09.
♂ M 1. 6/2.....17.....hatched; dead 9/5/08.	CC 2. 11/11.....30.....hatched; died 2/10/09.
♀ M 2. 6/4.....18.....hatched; dead 9/14/08.	DD 1. 11/19; no development; neglect (?).
N 1. 6/10; failed.	DD 2. 11/21; no development; neglect (?).
N 2. 6/12; failed.	EE 1. 11/28; hatched; not fed.
♀ O 1. 6/19.....19.....hatched; dead 9/19/08.	EE 2. 11/30; fully developed embryo.
♂ O 2. 6/21.....20.....hatched; dead 9/25/08.	Parents removed 12/1/08.

(Sh 6/13)

NOTE.—The second egg was less fertile, or produced a bird clearly less strong, in 7 cases; the first egg showed the same in 1 case.

⁶ These three tables were prepared in their complete and present form by the author.

⁷ "November 6, 1908. The pigeons have been doing less and less since August and are now pretty near the lowest ebb. I have only 2 pairs of common pigeons (out of 10 pairs) with eggs and 2 with young." (R 16)



Neck-mark in *Streptopelia risoria*.

- A. The separate feather is the darkest one from the neck-mark (left-side). $\times 3$.
 B. Juvenal ring-dove; same as figure C. Hayashi del., July 1902.
 C. Juvenal ring-dove; 6 weeks old. $\times 1.2$. Hayashi del., July 1902. For comparison of juvenal neck-mark in other doves. The darker feathers of mark begin here in *two loci*, lateral and posterior.
 D. Adult female ring-dove. $\times 2$. Apr. 25, 1902. The skin was split up in middle of neck (in front) and spread out to show entire ring; outside feathers pulled out. Five rows of feathers in each half (right to left) of ring, but 3 rows make most of the ring. At extreme upper and lower margins of the ring are feathers with lighter tips.

lightly over it at this time. Other items of interest are found in the tables, and these may be consulted by those who are interested in these topics.

These ring-doves are so highly fertile that but few instances of "no development" or "failed to hatch" are to be found in the records. There are a few such cases, however, and they are associated with the following months: December (table 174), January (table 175), August (table 176), June (one case), and November (three cases, table 177).

Sex and egg of clutch.—It has previously been noted (table 167) that the above group of blond rings threw 19 males and 21 females. It may now be observed that these pure rings produce males more often from the first egg of the clutch and females more often from the second. The cases recorded in these tables furnish 8 instances in which the two sexes were produced by the same clutch. In 6 of these the first egg gave rise to the male and the second egg yielded a female; in 2 cases this order was reversed.

TABLE 170.—*Relation of sex to first and second egg of clutch in pure Stig. senegalensis.*

Parents.	Sex and clutch.	Date.	Dead.	Length of life.	Parents.	Sex and clutch.	Date.	Dead.	Length of life.
				yr. mo.					yr. mo.
Pair 1	{ B 1	4/20/08	11/19/09.....	1 7	Pair 3	{ ♂ J	5/21/09	8/20/09.....	8
	{ ♀ B 2	4/22/08	12/ 3/08.....	7½		{ No second egg.			
..	{ ♂ D 1	7/23/08	Alive 1914.....	6+	..	{ ♂ K 1	7/ 5/09	8/26/09.....	1½
	{ D 2	7/25/08	8/13/08.....	½		{ K 2	7/ 7/09		? 2+
Pair 2	{ A 1	4/26/08	(?) alive 1910.....	? 2+	..	{ ♂ L 1	7/30/09	11/27/09 (cure ?)...	4
	{ ♀ A 2	4/28/08	9/20/08.....	5		{ ♀ L 2	8/ 1/09	11/27/09 (cure ?)...	4
..	{ ♀ C 1	6/30/08	11/24/08.....	5	Pair 4	{ ♂ B 1	9/ 1/10	1/25/12.....	1 5
	{ C 2	7/ 2/08		? 5+		{ ♀ B 2	9/ 3/10	Alive 1914.....	4+
..	{ ♀ F 1	10/19/08	2/ 8/09.....	3½	Pair 5	{ ♂ A 1	3/30/10	11/26/13.....	3 8
	{ F 2	10/21/08	11/28/08 (cold)...			{ A 2	4/ 1/10	Died early (cold)...	
Pair 3	{ ♂ A 1	5/ 5/08	10/19/08.....	5½	..	{ ♂ C 1	6/ 3/10	8/21/13 escaped.	3+
	{ A 2	5/ 7/08	(?) alive 1910.....	2+		{ C 2	6/ 5/10		
..	{ ♂ B 1	5/14/08	8/ 9/08.....	3	Pair 6	{ A 1	4/ 1/10		? 7+
	{ B 2	5/16/08		? 3+		{ ♀ A 2	4/ 3/10	10/10/10 (food ?)	6+
..	{ ♂ D 1	7/ 3/08	Alive 1910.....	2+	..	{ C 1	6/15/10		
	{ D 2	7/ 5/08	11/19/09.....	1 4½		{ ♀ C 2	6/17/10	2/ 8/13.....	2 8
..	{ F 1	9/ 2/08		? 2+	..	{ D 1	7/16/10		
	{ ♂ F 2	9/ 4/08	Alive 1910.....	2+		{ ♀ D 2	7/18/10	3/16/12.....	1 8
..	{ G 1	10/ 9/08		? 5+	..	{ ♂ E 1	9/11/10	11/21/11.....	1 2
	{ ♀ G 2	10/11/08	3/ 5/09.....	5		{ ♂ E 2	9/13/10	1/29/12.....	1 4½
..	{ ♂ I 1	3/11/09	7/30/09.....	4½	Pair 7	{ C 1	7/30/10		
	{ I 2	3/13/09	Unhatched.....	0		{ ♀ C 2	8/ 1/10	11/19/10 (cold)...	3+
Total..	{ 12 ♂'s from first egg; 2 ♀'s from first egg. 2 ♂'s from second egg; 9 ♀'s from second egg.								

TABLE 171.

♂ Phaps chalcoptera; from dealer 10/30/03.

♀ Phaps chalcoptera; from dealer 10/30/03.

Pair 1.

♂ A 1. 6/11/05. D 1. 9/29.
 ♀ A 2. 6/13/05. ♀ D 2. 10/1.
 ♂ B 1. 7/13. ♂ I 1. 5/3/06.
 ♀ B 2. 7/15. I 2. 5/5/06.
 ♂ C 1. 7/25.
 ♀ C 2. 7/27.

Pair 2.

♀ A 1. 9/8/05; hatched. ♂ C 1. 1/3/06.
 A 2. 9/10/05; no development. ♀ C 2. 1/5/06.
 ♀ B 1. 10/1; lived several months. D 1; no record.
 B 2. 10/3; dead at week. D 2; no record.

(RR 33)

We may here list the sex-relation of the 2 eggs of the clutch as it is displayed in the records of the several matings and species dealt with in the present chapter.⁸ If A be allowed to represent "pairs of eggs" in which the first egg produced a male and the second a female, and B the reverse, we then may read as follows:

	A	B		A	B		A	B		A	B
♂ senegalensis	II	1 ¹	senegalensis-alba	2	II	senegalensis	I	1 ¹	chinensis	I	II
♀ alba			risoria			risoria			suratensis		
♂ senegalensis	2	0	risoria	6	2	chalcoptera	4	0	suratensis	4	3
♀ senegalensis			risoria			chalcoptera			suratensis		
	II	I		8	2		5	I		5	3

¹ These birds hatched from the first or last clutch of the season.

It thus appears that from all of these "pure-bred" females, representing several different species, the first eggs of the clutch more often produce males and the second more often females. This has been noted in previous chapters to hold for the species considered there. A further word concerning this general situation should doubtless be added.

From the time of Aristotle to the immediate present there have appeared statements concerning a predominance or a lack of predominance of males from the first egg and of females from the second egg of the pigeon's clutch. It is quite unnecessary to discuss at length any of these divergent reports. They have all been based on a general statistical method, which is a wholly inadequate and useless method for a study of the problem. It is clear from all that has preceded in this volume that the method that would be valuable must be an *analytical* one. The author has laid the foundation, and fashioned much of the superstructure, of a proper analytical study of this point. He has shown that from the periods of the production of

TABLE 172.

♂ Cham. talpicoti. ♀ Cham. talpicoti.	♂ Ch. talpicoti; (imported 1909). ♀ Ch. talpicoti; (imported 1909).
♂ A 1. hatched....1...6/1/08....dead 12/26/11. A 2. hatched....2...6/1/08. B. hatched....3...7/10. C 1. hatched....4...8/5. C 2. hatched....5...8/6. D 1. 8/14; no development. D 2. 8/16; no development. E 1. hatched; 9/28; died very soon. E 2. hatched; 9/28; died very soon.	♂ A 1. hatched....6...6/25/09; possibly alive 1/1/15. A 2. hatched....7...6/25/09; shade darker than A 1. ♂ Ch. talpicoti (6); hatched 6/25/09. ♀ Ch. talpicoti (0). A 1. hatched....8...June (?) 1910. A 2. hatched....9...June (this bird or sire (6); alive 1/1/15). B 1. hatched....10...July (?). B 2. hatched....11...July (?). C 1. hatched....12...August. C 2. hatched....13...August. D. 1 8/31 } one hatched, died at one week; one, no develop- D. 2 9/2 } ment. (Sh 20/13)

TABLE 173.

♂ Geotrygon sp. ♀ Geotrygon sp.		
A 1. 7/14/02; hatched. A 2. 7/16/02; hatched. B 1. 8/12; hatched. B 2. 8/14; hatched.	C 1. 9/25; no development. C 2. 9/27; hatched. D 1. 10/11; hatched. D 2. 10/13; hatched.	E 1. 8/20/03; broken. E 2. 8/22/03; broken. F 1. 10/19; hatched. F 2. 10/21; hatched. (Sh 23/13)

⁸ Only matings in which the female is "pure bred" (not hybrid) are tabulated. The proportion of males and females from the 2 eggs of the clutch in other species, or in matings of some of the above species with still other forms, has been considered in the several previous chapters; i.e., in connection with the fully tabulated records.—EDITOR.

the "strongest germs" an undue proportion of "pairs" of eggs produce males and that from the opposite period there arise undue numbers of pairs of eggs that produce females. To lump these altogether and to count the number of males arising from first and females from second eggs is plainly to cover up or lose the significance of the intervening pairs of eggs which bear the significant data. Again, many matings, because of exceptional strength or of weakness, will yield a considerable total predominance of males or of females, and the statistical method lumps all without thought or care of the cancellations and unsatisfied cancels involved; all of which as easily contributes to a "smoothing" of the results, as it does to a "smothering" of them.⁹

But it has been demonstrated by the author that not only is the *method* previously employed gravely at fault, but that the *material* used, in nearly all of those cases where the worker has thought it worth while to mention what form was studied, has been wholly unsuitable for leading to a decision; that is to say, the "pigeons" used were in most cases one or another of the 150 "mongrels" collectively known as domestic pigeons. One of the clearest points of our present knowledge of the relation of sex to egg of clutch is that the normal relations of these *are lost immediately upon hybridization*—i.e., in passing from the pure state of the species. The countless degradations and crossings suffered by the various "domesticated breeds" of pigeons since their existence as a pure wild species is, therefore, a sufficient index of the unsuitability of this material in a study of this subject.

Among all of the published statements to date, only in that of Cuénot does one find even a suggestion which points in the direction of recent findings and toward a reconciliation or understanding of the discordant data hitherto reported. Cuénot¹⁰ suggested that sex-production from the pigeons' clutches *may vary in the different races and subraces of pigeons*. This point, if applied to some domestic races, as compared with some pure wild species, would certainly be wholly true; possibly it is true also among the races and subraces of which he speaks.

It now seems certain that in many wild species of pigeons the rule is for the first egg of the clutch to produce a male and for the second to produce a female. It also seems probable that this order is normally reversed in some other wild species.¹¹ It is probable, moreover, that included in some species which normally produce a predominance of males from first and of females from second eggs there are exceptional individuals which quite regularly present the sexes in the reverse or in an irregular order. But these subsidiary points, together with the frequency of the reversals of order of the sexes in the "very first clutch" of the season (possibly also in the very last clutch under certain conditions) have not been adequately dealt with by the author, nor are they satisfactorily decided by his data; they must therefore await further and future analysis. These particular topics have been under investigation by the editor during the past 4 years. A large amount of data, obtained from several different lines of study, is still being accumulated and will probably not be long delayed in publication.

⁹ "Statistical results, giving the averages of many cases, give the average of chances. We want to know what happens under normal or prescribed conditions, with chance eliminated to the utmost. Statistics lead away from the careful study of the individual cases, on the assumption that such cases can not be understood except in the mass, where individuals are lost. It is evident that the result in *any case* depends upon *all of the particulars*, and the more thoroughly these are understood the better the result can be understood." (W 8.)

¹⁰ Bul. Sci. France et Belg., vol. 32 (5th ser., vol. 1), 1899.

¹¹ Possibly the purity of these species should be questioned.

TABLE 174-175.—Record of family A.

♂ St. risoria (A) from dealer late 1894; alive 10/1/97; 3+ yr.
 ♀ St. risoria (A) from dealer late 1894; dead 10/10/97; 3+ yr.

Clutch.	Date of laying.	Time between eggs.	Since previous set (in days).	Hatched.	Incubation.	Size.	Wt. in grams.	Age at laying.	Sex.	Remarks.
B	Apr. 21, 1895.		1st egg of year ¹	May 6, 1895.	15 days ²			10 mo. 1 da.	♀	Sex evident at 10 weeks old.
C 1	May 26.		35	June 12, or earlier	14+ days				♂	Size indicated ♂ was from C 1.
C 2	May 28.			June 12, or earlier	14 days (?)			6 mo. 5 da.	♀	
D 1	July 1, 4 to 5 p.m.			July 15; night.	14 days				♀	{Vide, "Instinct supposed male of pair 'D' turns out a female." (in Chapter III, Vol. III.—En.)}
D 2	July 3, 7 ^h 02 ^m a.m.	1 da. 15 to 20 hr.	2 36	July 17, 9 to 12 a.m.	14 days ²	2d smaller than 1st		6 mo. 11 da.	♀	
E 1	Aug. 1, 2 to 6 p.m.		2 31	Aug. 16, 9 a.m. to 1 p.m.	14 da. 15 to 19 hr.	2d larger than 1st		6 mo. 18 da.	♀	No eggs laid in first nest (Feb. 8, 1896).
E 2	Aug. 3, 8 to 1 p.m.		44	Aug. 16-17, night.	14— days			6 mo. 16 da.	♀	Unmated.
F	Sept. 14, 2 to 6 p.m.			Sept. 29.	14+ days				♂	{Eggs laid on railway journey (Boston to Chicago); both young of light color.
G 1	Oct. 23, 3 ^h 30 ^m to 4 ^h 30 ^m p.m.		2 39	Nov. 7, 1 ^h 30 ^m to 2 p.m.	14 da. 22 hr. ²				♀	Dissected May 4, 1896.
G 2	Oct. 25, 12 ^h 30 ^m to 1 ^h 30 ^m p.m.	Nearly 2 da.		Nov. 8, 9 p.m. to 6 a.m.	14 da. 12 hr. ²			4 mo. 20 da.	♀	This second egg remarkably small.
H 1	Dec. 26, 3 to 6 p.m.		2 64	Jan. 10-11, 1896, night	15 days ²	29.8 by 23	8.495		♂	
H 2	Dec. 28, 8 to 10 a.m.	1 da. 15 to 19 hr.		Failed to develop.		29.7 by 20.5	6.235		♀	
I 1	Feb. 4, 1896, 4 to 6 p.m.		40	Feb. 19, 1 ^h 30 ^m to 2 p.m.	14 da. 20 to 22 hr.	29.5 by 23	8.321		♂	
I 2	Feb. 6, 1896, 9 ^h 40 ^m a.m.	1 da. 16 to 18 hr.		Feb. 19, 10 p.m. to 6 a.m.	14 da. 4 hr. ²	31.0 by 23	8.685		♀	
J 1	Mar. 12, 4 to 6 p.m.		37	Mar. 28, 12 to 6 a.m.	15 da. 8 to 10 hr.	29.25 by 23	8.215		♂	
J 2	Mar. 14, 8 to 9 a.m.	1 da. 15 to 16 hr.		Mar. 28, 12 to 6 a.m.	14 da. — 4 hr. ²	30.0 by 23	8.525		♀	
K 1	Apr. 15, 4 to 5 p.m.		34	Apr. 30, 5 to 7 a.m.	14 da. 12 to 15 hr.	29.0 by 23	8.120		♂	
K 2	Apr. 17, 8 ^h 38 ^m a.m.	1 da. 15 hr. 38 m. (to 16 hr. 38 m.)		Opened May 1, 3 p.m.	14 da. 12 to 15 hr.	30.0 by 23.5	8.884		♂	Dissected May 7.
L 1	May 13, 5 ^h 15 ^m to 5 ^h 45 ^m p.m.		28	May 27-28; morning(?)	14 da. 12 hr.	30.0 by 23	8.587		♀	Dissected May 4.
L 2	May 15, 8 to 8 ^h 30 ^m a.m.	1 da. 15 to 16 hr.		May 28-29; morning(?)	14 da. — 4 hr. ²				♀	
M 1	June 18, 4 ^h 40 ^m p.m.		36	July 3, after 8 p.m.	15 da. 4 to 16 hr.	29.5 by 23.5	8.672		♀	
M 2	June 20, 8 to 8 ^h 45 ^m a.m.	1 da. 15 to 16 hr.		July 4-5, 8 p.m. to 8 a.m.	14 da. 12 to 24 hr.	21.0 by 23.5	9.557		♂	No 2d egg laid.
N 1	July 25, 4 ^h 35 ^m p.m.		37	Aug. 9, 5 to 6 a.m.	14 da. 12 to 13 hr.	30.0 by 23.5	9.022		♀	Dead 12/25/96.
N 2	July 27, 7 ^h 36 ^m a.m.	1 da. 15 hr. 1 m.		Aug. 10, 12 ^h 30 ^m p.m.	14 da. 5 hr.	31.5 by 23.5	9.325		♂	Dead 12/4/96.
O	Aug. 31.		37 days	Sept. 16, 1896.	Usual time.				♀	Both dissected.
P 1	Oct. 15.		45 days	Oct. 31.	15 da. 20 hr.				♀	No 2d egg laid.
P 2	Oct. 17.	1 da. 15 to 16 hrs.		Oct. 31.	14 da. 5 to 6 hr.				♂	Dead 12/25/96.
Q 1	Dec. 21.	Longer than usual.	67 days	Jan. 6, 1897.	15 da. 8 to 12 hr.				♀	Killed 2/15/97.
Q 2	Dec. 23.			Jan. 6, 1897.	14 da. 3 hr. 40 m.					
R 1	Jan. 28, 1897.		38 days	Feb. 13.	14 da. 3 to 4 hrs.					No development.
R 2	Jan. 30, 1897.	1 da. 16 hrs. 41 m.								No later record.
S 1	Mar. 4.		35 days	Not incubated.						Parents given other eggs till 3/21.
S 2	Mar. 6.	1 da. 16 hrs. 44 m.		Not incubated.						{7 day embryo killed.
T 1	Mar. 27.		23 days							{7 day embryo killed. (C 7/16)
T 2	Mar. 29.	1 da. 15 hrs. 51 m.								

¹ This also probably the first egg in life for this female.² Indicates nearly the exact time.

TABLE 174-175 (continued).—Record of family A.

♂ *St. risoria* (A) from dealer late 1894; alive 10/1/97; 3+ yr.♀ *St. risoria* (A) from dealer late 1894; dead 10/10/97; 3+ yr.

Clutch.	Date of laying.	Time between eggs.	Since previous set (in days.)	Hatched.	Incubation.	Remarks.
U 1	Apr. 27	1 da. 16 hrs. 7 m.	31 days	Not incubated		
U 2	Apr. 29			Not incubated		
V 1	June 2	1 da. 14 to 15 hrs.	36 days	Not incubated.		
V 2	June 4			Not incubated.		
W 1	June 23		21 days.			{Egg broken.
W 2	June 25					{Egg broken.
X 1	July 20		27 days	Aug. 4	14 da. 12 hrs. ¹	Killed at few days.
X 2	July 22					No record.
Y	Aug. 14		25 days.	Not incubated.		No second egg.
Z 1	Sept. 14		31 days	Sept. 29	Usual time.	{These eggs incubated during rail- way journey. (C 7/16)
Z 2	Sept. 16			Sept. 29		

¹ Indicates nearly the exact time.

TABLE 177.

♂ *St. risoria* (C); hatched 6/12/95; brother; 8/?/00; 5 yr. 2 mo.♀ *St. risoria* (C); hatched 6/12/95; sister; lived longer than mate (above).

Birds were 6 months and 5 days old when first eggs were laid.

♂ A 1. 12/17/95. 8.335 g. weak (poor feeding); killed 3/25/96.

♂ A 2. 12/19/95. 8.118 g. weak (poor feeding); killed 3/25/96.

B 1. 1/31/96; thin shell; broken.

B 2. No record.

♂ C 1. 2/8. 7.984 g. killed 5/11/96.

♂ C 2. 2/10. 8.241 g. killed 5/4/96.

♀ D 1. 3/13. 8.630 g. hatched.

♂ D 2. 3/15. 9.225 g. hatched.

♀ E 1. 4/13. 8.489 g. hatched.

♀ E 2. 4/15. 8.838 g. hatched.

♂ F 1. 5/12. 8.720 g. killed 6/25/96.

♂ F 2. 5/14. 9.256 g. killed 6/2/96.

G 1. 6/12. 8.972 g. failed to hatch.

♀ G 2. 6/14. 9.365 g. killed 9/2/96.

H 1. 7/10. 8.692 g. embryo killed.

H 2. 7/12. 9.520 g. embryo killed.

I 1. 7/27. 8.425 g. not incubated.

I 2. 7/29. 9.120 g. not incubated.

J. 11/2; some development.

K 1. 11/26; some development.

K 2. 11/28; fully developed; pipped; failed to hatch.

L 1. 12/23; hatched.

L 2. 12/25; hatched.

(C 7/17)

These birds were kept mated and laid numerous eggs during 1897 (22 eggs), 1898 (16 eggs), 1899 (18 eggs), and 1900 (7 eggs). The male died 8/?/1900. Few of these eggs were incubated—this pair being used to nest the eggs of other birds. Nevertheless 6 eggs were hatched in 1897, 6 in 1898, and 8 in 1899. The length of life of all these young is unknown.—EDITOR.

TABLE 176.—Record of family G.

♂ *St. risoria* (G); 7/25/99.♀ *St. risoria* (G); 10/23/95 to 7/25/04; age 4 mos. 20 da. at time of first laying.

Clutch.	Laid.	Time between eggs.	Since previous set in (days).	Hatched.	Incubation.	Weight of egg.	Remarks.
B	Mar. 27, 1896.					5.900	One egg only; thin shell.
C	Apr. 11.		15				One only; laid from perch.
D	Apr. 18.		7			6.560	One only; thin shell.
E	Apr. 26.		8				One; good shell. ¹
♀ F1	May 4.	1 da. 15 to 16 hrs.	8	May 19, 4 ^h 15 ^m p.m.	15 days.	7.462	Killed Jan. 27, 1898.
♂ F2	May 6.			May 20, 12 ^h 50 ^m p.m.	14 da. 4 to 5 hrs.	8.285	Died July 17, 1897.
G	June 17.		44		14 da. 15 to 20 hrs.	7.745	Killed at hatching.
H1	July 14.	Usual time.	27			8.508	Killed July 22.
H2	July 16.					8.805	Killed July 22.
I1	Aug. 21.	1 da. 14 hrs. 48 m.	38	Sept. 5, before 6.	14 da. 13 hrs.		
I2	Aug. 23.			Sept. 6, before 7.	13 da. 22 to 23 hrs.		
J1	Sept. 25.	Usual time.	35				Eggs lost.
J2	Sept. 27.						
K1	Nov. 1.	1 da. 15 to 16 hrs.	37	Nov. 16, 1 p.m.	14 da. 20 hrs.		Dead (food), Nov. 21.
K2	Nov. 3.			Nov. 17, 1 to 2 p.m.			Dead (food), Nov. 23.
L	Dec. 23.	On nest but failed to lay.					
M1	Jan. 1, 1897.	1 da. 18 hrs. 2 m.	9 or 61	Jan. 16, 3 ^h 20 ^m p.m.	15 days.		
M2	Jan. 3.			Jan. 17, 12 (?) m.	14 da. 3 hrs. (?)		Dead Jan. 17, 1897.
N1	Jan. 14.		13				Broken.
N2	Jan. 16.						
O1	Jan. 24.		10	Feb. 8, early a.m.			Dead Feb. 14, 1897.
O2	Jan. 26.			Feb. 9, 2 p.m.	14 da. 4 to 6 hrs.		
P1	Mar. 6.	1 da. 16 hrs. 42 m.	41	Mar. 21, early a.m.	14 da. 12 hrs. (?)		
P2	Mar. 8.			Mar. 22, 2 p.m.	14 da. 4¼ hrs.		
Q1	Apr. 12.	1 da. 16 hrs. 39 m.	37				
Q2	Apr. 14.						
R1	Apr. 19.	1 da. 15 hrs. 44 m.	7	No record.			
R2	Apr. 21.						
S1	May 20.	1 da. 15 hrs. (?)	31	No record.			
S2	May 22.						
T1	June 12.	1 da. 15 to 16 hrs.	23	June 27, 5 to 6 a.m.	14 da. 12 to 13 hrs.		
T2	June 14.			June 28, p.m.	14 da. 4 to 6 hrs.		
U1	July 19.	(?)	37	Aug. 3.	No record.		
U2	July 21.			Aug. 3.	No record.		
W1	Aug. 24.	1 da. 14 to 15 hrs.	36	Did not hatch.			
W2	Aug. 26.			Sept. 9, a.m.	14 da. (?) h.		
X1	Oct. 7.		44	Removed Oct. 16.			
X2	Oct. 9.						
Y1	Dec. 14.		68	Jan. 31 to Feb. 1.			
Y2	Dec. 17.						
Z1	Feb. 19, 1898.		67	Mar. 6.	14 da. 19 to 21 hrs.		
Z2	Feb. 21.		67	Mar. 7, 5 to 6 a.m.	13 da. 21 to 22 hrs.		
AA1	Mar. 30.		39	Removed.	No record.		
AA2	April 1.						
BB1	Apr. 27.		28	Hatched.	No record.		
BB2	Apr. 29.			Hatched.			

(C 7/20)

¹ This egg removed April 29.

CHAPTER XIV.

ON THE NATURE AND BASIS OF HEREDITY.

Parts of two addresses and a considerable amount of less closely written materials have been seriated by the editor to form the present chapter. The three groups of materials are here placed in the order of their preparation, and under their original titles.

HEREDITY.¹

The subject of heredity covers a wide field, and the central problem has been scarcely more than located. It has long been obscured with traditional myths, which, like other traditions, often live in one disguise or another after they have been repudiated. One of these myths, if one may venture to so classify it, is the idea that heredity stands for "transmission," with emphasis placed on the *trans*.

The Century Dictionary defines heredity as "the influence of parents upon offspring; *transmission of qualities or characteristics, mental or physical, from parents to offspring.*" The essential idea here is contained in the word "transmission." The characters of the offspring are conceived of as inherited, as if they represented elements that belonged primarily to the parents and were by them bequeathed as legacies to their children.

We may flatter ourselves that we have completely outgrown such a crude conception, but the traditional term continues in everyday use, and the traditional idea still cleaves to it. Witness the belief still held by a considerable number of naturalists—which not long ago was so ably championed by Herbert Spencer and as ably controverted by Weismann—the belief handed down from Lamarck, that "characters" functionally acquired during the lifetime of the parents are transmissible to the offspring.

Darwin's pangenesis and the intracellular pangenesis of de Vries represent elaborate systems of transmission, in which the central myth expands into a train of ancillary myths, each designed to conceal the weakness of the mother myth. Darwin ends his discussion of pangenesis with the following words:

"Each living creature must be looked at as a microcosm—a little universe, formed of a host of self-propagating organisms, inconceivably minute and as numerous as the stars of heaven"² (Animals and Plants, II, p. 483).

Darwin's hypothesis represented the germ-cells as composed of these "hosts of self-propagating" pangens, collected from every point in the body. Think of these

¹ The manuscript treating of this topic represents that portion of a lecture at Woods Hole, July 29, 1907, that was reduced to writing (SS 12). It is given first position in this chapter because of its consideration of the more general aspects of development. The method of treating the subject, adopted by the author in these pages, suggests that this material more properly belongs with the chapters on Orthogenetic Evolution, in Volume I. But the fact that three quite different *aspects* of heredity are considered in these three groups of materials led to the conclusion that no one of the three aspects of the subjects should be presented as an isolate. The two additional parts of the chapter are: A part of a lecture (on Mendelian heredity), of February 28, 1908, before the Wisconsin Natural History Society (Z 5), and, finally some short, sketchy materials (R 16, WW 1, EM 9, W 9) which the author had not yet arranged in final manuscript form, but which constitute his last writings and conclusions on matters of much interest to the present volume, chiefly on "germinal weakness" and evidences of it and of its modifiability.—Ed.

² This passage is adopted by de Vries as a motto to adorn the title page of his "Intra-cellular Pangenesis."

hosts of atoms migrating from all parts of the body and assembling in germ-cells. This miraculous migration is then followed in the developing germ by an equally marvelous "distribution" of these atoms to their appointed places. Here transmission includes two distinct steps—a "centripetal migration" and then a "centrifugal redistribution" to points corresponding to the points of departure.

De Vries abbreviates this hypothesis of transmission by cutting out the first step completely, for he imagines that his hosts of unit-characters are located in the nucleus from the first, and hence that they require no transportation from the soma. The myth of centripetal migration is dismissed, but that of centrifugal distribution is retained. The abbreviation, then, although in the right direction, amounts to nothing as a simplification, for miracles are not made more comprehensible by reduction in number.

We have to discard the idea of transmission *in toto*, not only the centripetal migration conceived by Darwin, but also the centrifugal emigration or distribution from the germ-nucleus to the soma.

Every theory founded upon the postulate of unit-characters, or specific determinants stored in the nucleus, is necessarily committed to some form of centrifugal distribution during the course of development; and for each element to be distributed it is necessary to assume either that it is passively transported to its destination or that it finds its own way automatically. In either case it would be nothing less than a miracle for a specific pangen to reach a prescribed point in such a complex mosaic field as the organism represents; and, for this to be fulfilled, not only at the predetermined point, but also at just the moment for harmonious development with its immediate neighbors, with symmetrical and correlated groups, with inter- and intra-locking systems, constituting a microcosmic whole, incomparably more difficult to grasp than the stellar universe—for all this to be fulfilled is utterly beyond the bounds of scientific credibility. To try to conceive of normal development as thus prepunctuated in all its space and time relations—as proceeding from ready-made elemental characters, automatically distributing themselves or guided by entelechies—is to indulge in ultra-scientific teleology.

When we take from these pangen deities all that speculation has fictitiously injected into them, or wrapped around them, nothing remains but physical elements in self-sustaining organic relations. In brief, we have a primordial germ-cell of the same specific constitution as the mother-cell that preceded it. The mother-cell transmits *nothing*. When it divides into two daughter-cells it merely divides itself, and each moiety has the constitution it had before division. If, then, the daughter-cell is an exact copy of the mother-cell there is no wonder, since it really is the mother-cell in substance, constitution, behavior, and potentialities. It is all this, and yet no transfer of qualities has taken place, and it is plain that *transference or transmission is absolutely impossible, in the nature of the case*.

Our germ-cell, which inherits nothing—unless, under the spell of usage, we must still continue to say that a cell inherits itself—our germ-cell is from the first a living organism, for it has all the fundamental functions of living organisms, such as assimilation, growth, reproduction, etc. It is in the exercise of these functions that development becomes a *progressive elaboration*, with a physical continuity that admits of periods of comparative rest, but not of breaks in causal sequence.

As the organic world must, from the standpoint of evolution, be regarded as a product of the physical world, we have always to take the physical aspects as our point of departure. Our theoretical myths are largely due to reversing this natural mode of procedure, not meaning to imply that from the physical side we always come face to face with facts. Newton's emission or corpuscular theory, according to which light consists of particles emitted from the luminous body, was just as much a myth as the theory of transmission of hereditary qualities. The emission conception proved to be untenable and had to give way to a totally different view, according to which light is not something transported from the sun, but a peculiar self-propagating motion of the ether.

Now, the ether set in vibration at the sun does not of course come to us, neither does the initial vibration ever reach us. A ripple may appear to run over the surface of water, but the appearance is illusive. The ripple is a new ripple at every instant, and its seemingly running crest does not advance at all. So with the vibrations of the ether. Successive particles vibrate in linear sequence, because they are identical in nature and respond alike to the same condition. So also is it with hereditary phenomena. Germ-cells behave alike in development, not because anything is transmitted to them, but because they represent *identical material and constitution*, and are exposed to essentially like environmental conditions.

The development of the germ is said to end in the specific form characteristic of the race. It is well to remember that we have in every development a flowing sequence of specific forms, for every stage is as specific as the end-stage. In this progressive change of form we see an interesting difference between the development of the organism and the development of the crystal; nevertheless, the form is as certainly a physical determination in the one as in the other. The crystal has its specific form and sometimes several specific forms. In every case it owes the form to the nature of its material elements and the conditions under which it arises. We would not think of ascribing its form and symmetry to hereditary transmission; neither would we think of intercalating directing or formative agents, distinct from the material elements composing it.

Fundamentally considered, the organism and the crystal are equally "self-determining" at every step, equally the products of intrinsic physical properties and conditions. The crystal is said to grow by "accretion," the organism by "intussusception." But this is merely a superficial difference that does not affect the general standpoint. From a physical standpoint the essential thing is not where the elemental particles attach themselves, whether interstitially or superficially, *but that they attach themselves in a self-regulating, determinate way*, so that the typical form at every step is, to use Jensen's terms, *autogenic* rather than *allogenic*. In other words, the form is a "direct causal result," rather than an indirect one imposed by special mediative factors, such as pangens, determinants, and the like.

According to the view sketched, we see that *recapitulation* in the organic world is a universal phenomenon as fundamental as in the crystal world. It is no hallucination, but the great fact underlying every form of heredity, every form of development, every form of evolution.

Ontogeny is recapitulation from top to bottom. Think how full of significance is the recurrence of the cell-stage as the universal primordium in both plant and animal development. And yet no two species start with germ-cells that could be

interchanged. The germs of different species are specifically unlike, so that although they set out in very similar ways, they gradually diverge and end in all the varieties that inhabit the earth. Relatively slight initial differences are sufficient for greater and greater and more numerous differences as development runs on. All this is to be expected from a physical standpoint; special pangens to steer are superfluous; their theoretical importation explains absolutely nothing, and only leaves us with greater difficulties to account for than the phenomena themselves.

Ontogenetic recapitulation in a given species is most wonderfully exact. It is this perfection of reproduction that *seems* to require some extraordinary or supernatural agencies. We easily forget that *only physical processes can approach such exactness*. It is absurd to think such processes need or can have assistance in reaching exact results. The more we reflect upon this, the clearer it becomes that recapitulation must be physically directed, *i.e.* self-directing.

Ontogenetic recapitulation is, then, a fact that admits of no explanation except from a physical standpoint. In this fact lies the whole of heredity.

Now, while ontogeny is so wonderfully exact that we never cease to be amazed at its performances, we must not forget that germ-cells are subject to slow variation. In fact, it is only germ-variation that has to be considered in phylogeny as in ontogeny. Consequently, when the germ-cell takes a step forward, ontogeny begins with an initial difference that sets the whole series of ontogenetic stages on a diverging line that digresses so little as to be undiscoverable until near or at the end of development.

Succeeding generations start with recapitulation at the new level or at the new point in the same level. As variation in the germ moves, so the recapitulation shifts; to be physically exact it must do so. Variation in results, then, is no evidence of a fault in exactness, and the shift is so slow that recapitulation is closely ideal.

ON MENDELIAN HEREDITY.

In an address of last year,³ I had no occasion to do more than refer to Mendel's brilliant work. Although Mendel did not undertake to formulate any theory of evolution, the problem of the origin of species was certainly in his mind, and he hoped to get some decisive results by crossing varieties or species. A finer model of experimental work and careful analysis has not been seen. The results were very remarkable and are now accorded first rank by many prominent naturalists.

I have devoted a good deal of time during the last 10 years to crossing various wild and tame species of pigeons, and do not intend at this time to go deeply into the subject of hybridization, but may refer briefly to some experiments which lead me to believe that Mendel's experiments with different varieties of peas, important as they are, do not reveal any fundamental and universal law of heredity.

Mendel saw clearly that the problem of the origin of species must be attacked from the analytical and experimental side. The first step, then, was to select particular "specific characters" that were as sharply defined as possible. He selected 7 pairs of contrasting characters. For example: *tall* and *short* stem; *axial* and *terminal* flowers; *smooth* and *wrinkled* seeds; *yellow* and *green* cotyledons; *gray* and *brown* seed-coats; *inflated* and *constricted* pods; *green* and *yellow* pods.

³ This part of the chapter is the latter part of a lecture delivered at the Wisconsin Natural History Society February 27, 1908. (Z 5)

When a tall variety was crossed with a short one, the result was that *all* of the offspring were *tall*; hence the character "tall" was called *dominant*; "short" was called *recessive*. The same result was reached with the other characters. When the hybrids were bred together both characters reappeared, and always in definite proportions: (A) 3 dominants to 1 recessive, (B) 1 dominant : 2 hybrids : 1 recessive.

The fact that the same ratio appeared in each one of the seven sets of experiments seemed to demonstrate several important points: (1) that there was some uniform law governing the results; (2) that specific characters stood for definite units—"purity of germs," as Professor Bateson calls it; (3) there were no transitional phases, no passing of one character gradually into another.

When thus presented, the facts tell strongly against the origin of species by gradual modification as held by Darwin, and strongly support the contention of de Vries for mutation as the mode of evolution. No wonder that the work was hailed with such delight by de Vries and Bateson.

On looking at the two classes of characters—the dominants and recessives—it becomes obvious that the results would not bear out the conclusions. For example, is it not clear that there can be no such impassable limit between "tall" and "short" as claimed? Whatever the ratio discovered means, it can not mean any absolute *impasse* between two such characters. In no case of these contrasting characters does it seem at all probable that there can be no transitional or intermediate conditions.

A simple question as to these pairs of dominants and recessives was this: Could one on hearing the names of the pairs predict which one in each pair would be dominant and which recessive? I took the list given by Mendel, and, before informing myself of Mendel's results, underlined the characters which I conjectured would be likely to be dominant. The guess turned out correct in every one of the seven cases.

The meaning of dominance and recessiveness is, then, only greater or less *vigor*, greater or less *stability*. In the case of "tall" and "short" it is vigor, in the case of axillary or terminal flowers it is preponderance of stability—the older character being the more firmly fixed. This is enough perhaps to be suggestive.

Now, we find differences in vigor and in the stability of characters everywhere, but we do not always get the Mendelian ratios. The ratios we get, if we get any at all, are quite different in different species, and that might have been foreseen. [Here the lecturer continued the subject without manuscript, and but few additional pages (see two paragraphs in advance) were ever written;⁴ the outline from which he spoke is of interest, however, and is as follows.—EDITOR.]

Mention—

(a) Results in crossing: Japanese turtle and blond ring-dove; Japanese turtle and white ring; Japanese turtle and homer; Japanese turtle and common pigeon; Hybrid and homer; White ring and *humilis*. First generation—dark ♂ and white ♀. European turtle and ring—♂ dark and light ♀. Japanese turtle and ring—♂ dark and light ♀. This seems⁵ to be a general law with pigeons, but I should not dare to say it holds as a universal law.

(b) Sex-alteration." (Z 5)

Mendel⁶ did not undertake to develop a theory of evolution, his aim being to discover the principles that govern hybridization. His experiment with peas, as he

⁴ The first part of Chapter I has a short statement on Mendelian heredity.—EDITOR.

⁵ That is, "dark male and light female" hybrids.—EDITOR.

⁶ Written December 1907 (before, or at the same time with, the immediately preceding pages).—EDITOR.

interpreted them, seemed to indicate that specific characters behave as "pure" and "independent" units. Mendel's results are now being tested in various forms, and it remains to be seen whether he discovered any principle that admits of universal application. So far as my own work goes, I may say I find no evidence of independent unit-characters, and I think that I find abundant evidence that specific characters do not pre-exist in germs, either as specific units or as determinants. In fact, the whole conception of characters as unit-entities seems to me utterly incompatible with what we know of their genesis and history.

It is quite true that as yet we have not seen very much serious work on the genesis of characters. It is very much easier to compile ponderous volumes of reported saltations and discontinuities than it is to trace these appearances to their genetic foundations. The criticism I should make of Mendel's work would be that he did not first study with the utmost care the nature of the characters with which he proposed to experiment.

Furthermore, the claim that any two characters in closely related varieties of peas should be "mutually exclusive" borders on the incredible, and stands in contradiction, as it seems to me, with the very general phenomenon of blending. The conception of characters as indivisible unit-entities seems utterly irreconcilable with all we know of the phyletic derivation of organs and characters. The "principle of change of function," developed so ably by Dohrn in 1875, shows that characters are only local differentiations that arise by slowly modifying processes.

The contrary assumption is the negation of evolution, and opens the way to the realm of miracle. There can be absolutely no hope of ever tracing the genesis of characters from the standpoint of Mendelian purity. We may get allelomorphs within allelomorphs *ad infinitum*, but every "within" hides the truth we are seeking, in essentially the same way that the old preformationists hid one miracle within another in the womb of mother Eve. (Z 6)

Some further data and conclusions bearing upon the preceding theme, and written mostly after the above, have been seriated and given a concluding position in this chapter by the editor:⁷

Mendel emphasized the importance of using safe material, but he overlooked the fact that his peas were *closely related varieties*, which fact may have something to do with *alternative inheritance*. Darwin and others have used domestic species.

"It is willingly granted that by cultivation the origination of new varieties are acquired which, under natural conditions, would be lost. . . . Various experiments force us to the conclusion that our cultivated plants, with few exceptions, are members of various hybrid series,⁸ whose further development in conformity with law is changed and hindered by frequent crossings *inter se*. The circumstance must not be overlooked that cultivated plants are mostly grown in great numbers and close together, which affords the most favorable conditions for reciprocal fertilization between the varieties present and the species itself."

The great variability of cultivated plants is, according to Mendel, due not so much to "simple transference into garden soil" as to the cross-breeding which is thus favored and which is systematically practised by the horticulturist.

⁷ All that follows was written at intervals, and more or less disconnectedly, by Professor Whitman. The editor is responsible for the order and arrangement of the material.

⁸ The italicizing is our own.

It is claimed that the peas form an exception, as their organs of fertilization are protected by the keel. But it is admitted that "even here there have arisen numerous varieties during a cultural period of more than 1,000 years; these maintain, however, under unchanging environments a stability as great as that of species growing wild."

Pigeons present the following advantages over peas in crossing: (1) In peas we can not put the individual to more than *one* test. In pigeons we can test an individual over and over again, one year after another; we can test it with different individuals of its own kind or by various crosses. This advantage enables us to see that the individual carries *different* (not necessarily "pure") germs. (2) Pigeons present phylogenetic stages (ageing), so that an individual gives us two well-marked phases for study—one in the first plumage and another in the second or adult plumage. (3) The characters, although more complex, are more definite, and give more than one differential. These points probably more than counterbalance the reality involved in the objection raised by Mendel and by Bateson that a multitude of characters might be an obstacle to discovering Mendel's law.⁹ (W 10)

De Vries's mutations¹⁰ make it impossible to investigate. Premutations are as immutable as mutations, and they are not supposed to come in gradually, but by a complete and sudden transformation.

Mendelism—pure germs, segregation, etc.—ignores the real thing, namely, *germ-variation*, and refers all changes in characters, in color for example, to germs introduced somewhere in the parent stock. It speaks of reversion, etc., as due to the cropping-up of old germs that have suddenly come into the field.¹¹ Changes due, for example, to weakening by inbreeding are all declared to be "segregation."

WEAK GERMS AND IRREGULARITIES IN DEVELOPMENT.¹²

White color.—Most students of genetics treat white as a character. Now, in albinos or partial albino pigeons and pheasants we have clear evidence that the presence of "patches of white" mean only that the organism is too weak to bring its development to the point of forming the normal color-pattern.

If this pattern represents many specific characters, as it does, then it is evident that in the case of a particular albino pheasant,¹³ to be described in the next paragraph, we have a lack of energy to carry out development, for this same albino gradually, in the course of 2 years, acquired nearly the full normal color with all the

⁹ Why is Mendelism found only in hybrids between "closely related" forms? We may observe that in closely allied species each parent represents *nearly all of the characters* found in the two species. If the two species stand wide apart, then each parent represents only a fraction that might descend to nearly one-half in extreme cases. In other words, the hybrid represents the *sum* of the *different* characters; e.g., suppose that in two close allies each has 10 characters, 9 of which are common; then the sum of the *different* characters would be $9 + 2 = 11$. Suppose each has 10 characters, 5 of which are common. Then the sum will be $5 + 5 + 5 = 15$. Suppose only 1 is common; then the sum will be $1 + 9 + 9 = 19$. The sum will increase as the number of common characters is smaller. Although each species has only 10 characters, the number of characters to be represented in the hybrid will vary from 11 to 19. (X. Z. W.)

¹⁰ De Vries's test of species by cross-fertilization can not be applied among the fungi; in many of these there is no fertilization, and when there is, it is self-fertilization. Among bacteria species can often be distinguished only by physiological means.

¹¹ It is probably true that the *species* changes throughout the whole life cycle.

¹² The arrangement of subjects under this heading is that of the editor. The descriptions and headlines are solely those of the author; the italics are also solely his.—EDITOR.

¹³ Many cases are known of old hen pheasants assuming male plumage. No cock pheasants were ever known to revert to female garb.

characters. Here is one case where we see that characters can not be said to pre-exist as definite units, the same bird may pass through several stages of patterns in succession, and we always see the transitions from one character to another. Similar examples could be drawn from the geopelias and other doves.

In 1905 I raised a whitened female pheasant which in her second year became nearly normal in color, but somewhat paler. From her and a normal male I obtained a partial albino male; but, strange to say, this two-thirds white male subsequently assumed gradually the color of the normal male, and finally when 2 years old had lost all white and presented the plumage of a normal male, except that the colors were not quite so dark.¹⁴

Albinism is, then, not one of a pair of opposite or alternative characters; it is only one of many degrees of the same color-character. Black pales to gray, and gray to various degrees of whiteness. In the pigeon the fancier's black, brown-gray, gray, red, yellow, all stand for one and the same kind of melanin pigment,¹⁵ differing only in density, depth, etc. The lighter colors and shades graduate into white, which, when closely examined, usually shows a tinge of yellowish or orange brown. If the pigment granules be examined by transmitted light we get an orange brown; if by reflected light, then black, red, yellow, whitish. Breeding shows that we pass easily from one of these conditions to another. The variations are all quantitative and conditional states of one and the same thing. Mendelian proportions may or may not appear, but these proportions are not to be construed as unit-characters, nor yet as immutable characters. I am convinced that these various shades of color are all due to one and the same character; in the development they are severally presented under different conditions.

In many animals we have a summer color and a winter white. Both are the same character, but in extreme conditions. The degree of exhibition may depend on the degree of heat, light, etc. How much simpler is this view than the assumption of two unit-characters, alternating in the same animal from summer to winter and back.

Physical weakness.—A juvenal pigeon (OS-D 3-G) hybrid from a male *orientalis turtur-risoria-alba* (OS 8-D 3) and a female blond ring, hatched July 18, 1908, has only 11 tail-feathers and 2 abnormal toes. The fourth toe of each foot has an abrupt bend at the end of the basal third, the distal two-thirds taking a direction nearly parallel with the middle or third toe. The result is "symmetrical" on the two sides. The tail, toes, and rather small size all indicate that this bird owes its deformities and deficiencies to *weakness in development*. (W 9) (The color of this bird—see table 57—too, was an abnormal gray, found in one other of its many sisters and brothers. This gray-colored bird (OS-D 3-G) arose almost immediately before a period of complete failure of developmental energy; the other abnormal gray was from the first egg after this period that was able to develop at all.—EDITOR.)

Weakness in common pigeons is frequently expressed in white color. Some white pigeons fail to get an orange-red iris. The irides of white ring-doves sometimes remain dark; the same is true in some common pigeons.

¹⁴ The author has recorded several instances of the appearance of white color due to quite temporary or accidental causes. It seems hardly necessary to refer to such cases in this work, since similar cases are well known to all naturalists.—EDITOR.

¹⁵ The editor has presented (Biol. Bull., 1909) evidence from chemical and developmental standpoints for this same conclusion, which was reached earlier by Professor Whitman.—EDITOR.

In a pair of young pouters from gray (white-barred Br  nn) pouters, one (8) is gray with dark bars, and in form is apparently very well developed;¹⁶ the other (9) is white, with poorly developed wings, the primaries being imperfectly developed.¹⁷ This bird has the "shakes"; that is, it trembles all over and can not control the movements of the head (I have had two such white birds from a dealer, and they are evidently of the same nature). This bird was hatched October 11, 1908, and at the age of 5 to 6 weeks, though of good appetite, was quite unable to fly. This white pouter died January 27, 1909, and turned out to be a female, as was its nest-mate, both hatched in October 1908.

In another case a pair of birds consisting of a male *orientalis* \times *risoria* hybrid (8) and a female *St. alba* hatched both eggs of a clutch on June 5, 1908; and again both eggs of another clutch on July 7. They laid again (third time) July 22 and 24, when the young from the second clutch were only about 2 weeks old and not yet out of the nest. This set of eggs, produced so early after the preceding eggs, failed to develop. Either this was due to the presence of young in the nest (the latter would prevent steady sitting) or to weakening of the germs (late in season) and to the strength of the old birds being reduced by the care of vigorous young.

Short abnormal legs.—In several crosses between common pigeons (*C. livia domestica*) and *T. orientalis* of Japan, I have had young hatched with legs abnormally short, so that in course of a few days, as the body rapidly grew, the legs came more and more to point more or less directly backward, and to be of no use in enabling the bird to reach up for its food.

So far as memory and some records serve, this condition did not appear in any of the first offspring raised in the better part of the season—April to June—but in the later offspring of July and August. This deformity may, then, be ascribed to failing or diminished *germ-energy*.

This view is confirmed again this season (1909) in a cross between a homer and a hybrid between *T. turtur* and *T. orientalis* (TO 8). The products of this cross (up to July 22) are as follows:

- First set of eggs, April 12 to 14, normal development.
- Second set of eggs, April 22 to 24, normal development.
- Third set of eggs, May 1 to 3, normal development.
- Fourth set of eggs, May 16 to 18, normal development.
- Fifth set of eggs, May 28 to 30, normal development.
- Sixth set of eggs, July 1 to 3, first, short legs; second, legs normal.

Note that I have worked these birds abnormally rapidly, and probably that, added to the usual strain, has been sufficient to weaken reproductive power. In the earlier part of season transference of eggs is followed by immediate renewal of the nesting cycle. In the later part of season the birds lose a week or more before renewing their efforts.

Distorted development, wry neck, dolicocephalism.—In 1906 I mated an imported male Japanese turtle with a female hybrid (SO 2) obtained in 1904 from a cross of *St. risoria* and *T. orientalis*. The result was one secondary hybrid (σ O-SO 2-B) which was able to live and mature. This bird has thus far proved *infertile*. He

¹⁶ A neat bird but a degenerate, as shown by color and also by her early failures to produce eggs.

¹⁷ The feathers of this bird were slow and irregular in growth; it was never able to fly, though it lived 3½ months. It was kept in the house and well cared for; no cause of death but weakness. The legs sprawled, so that walking was awkward and difficult; it was shaky like a fantail, and the primaries hung loosely apart.

showed the following marks of weak development: (1) the head is not quite erect, but has a noticeable cant to one side; (2) the back of the head is rather too large for the fore part; (3) a median crease, or division between the feathers of the breast, has never wholly disappeared, as it normally does with young birds becoming adult; (4) this bird has shown for a short time each season a desire to mate, but he has not been as energetic and persistent as perfect hybrids are.

Wry neck, complete lack of coördination of head and limbs.—A young hybrid (O 6-SO 2-B) hatched June 14, 1908, from a cross of a male *T. orientalis* (66) and female *risoria* × *orientalis* hybrid (2). It died at the age of only 5 weeks and 3 days. This bird showed deformities as follows: (1) the neck began to be bent to one side (left), the head being held with beak turned to the right; (2) the left eye (lower) seemed to be blind some time before death; (3) the legs sprawled apart and soon became of no service, the bird usually lying on its ventral surface supported by one or the other wing, the head usually resting on the floor; (4) the bird had to be fed by hand after about 10 days, since its head was so twisted that it could obtain no food from the old birds. It became quite accustomed to my feeding it and was quite eager for its food. In trying to move, however, the bird could only flop around, much as a headless fowl. It was utterly incapable of a single normal movement, except that it would open its mouth widely for food when I grasped its bill. The bird was faithfully fed along with a young white-faced pigeon. (5) It was dolicocephalic; the back of the head was prominent and bulging like the hybrid of 1906, referred to above. The wings were symmetrically developed, as was also the beak.

Here we see a distortion in the neck growing worse day by day until the end. The system of developmental processes is, at the beginning, a little unbalanced; later the distortion increases. The "character" is not then a "unit" at first, but something induced probably by weak organization.

Cross-bill.—The crossed-bill has been seen in several juvenal common pigeons; the curvature in one case amounted to nearly 90°. This deformity becomes visible a day or two after birth, but in some cases is already well-marked a few days before birth, as I learned through the following case: The second egg of a pair of hybrids (namely, *turtur* × *orientalis* × *homer* × *ring*) was laid July 9, 1908, and failed to hatch; after waiting an extra day I opened the shell and found the bird dead, but developed up to within about 2 days of the time to hatch. This bird showed a quite definite curvature in the upper mandible, which turned to the left.¹⁸

Infertility.—Developmental processes run on to different lengths. If equilibrium is disturbed, the deflection may become worse and worse—the deformity, being a local weakness, becomes less and less capable of veering to the normal. Do developmental processes run on *continuously*? An affirmative answer is given as a result of pulling out some of the first feathers prematurely. The color-pattern is thus found to have made progress in the feathers that follow.

Developmental processes may be arrested by cold or otherwise. May the same process run to different lengths, according to the greater or less strength or

¹⁸ In 1911 the editor recorded two cases of "curved-bill"—not certain whether "crossed"—in two *unhatched* birds from a mating of a male *St. alba* and a female *alba-orientalis* hybrid. Since that time a considerable number of cases of true "cross-bill" have been observed in various hybrids.—EDITOR.

energy? I think the male in many species of birds passes directly through and beyond the female stage. In many cases even the females may now and then pass beyond the normal female and advance towards the male condition. The energy of development and degree of fertility appear to be correlated. (W 6)

If fertility is a thing of all degrees, and that too within the limits of a single species, are not the qualitative distinctions inferred therefrom likewise things of degrees, and variable within the same limits? If fertility may vary individually, as is certain, is there any reason to doubt that its physical bases are equally variable from individual to individual? But fertility varies also according to age, conditions of food, temperature, etc. How then can qualitative differences be an infallible criterion of species?

We have weakness, not only in ova, but also in the spermatozoa of hybrids. Guyer¹⁹ showed that the sperm of hybrids (from wide crosses) do not come to full development. The hybrids on which he worked were hybrids between common pigeons and ring-doves, and these hybrids are practically all males. Among other hybrids from very wide crosses (as the common dove and Japanese turtle) I have had one fertile male. In hybrids between ring-doves and Japanese turtles I have had quite a number of fertile males and some females. As hybrids are taken between more and more nearly related species the sperm rises to more and more perfect development. As development is more complete, energy is more complete and fertility becomes highest.

Early fertility is often followed by later infertility.—For two years (1907 and 1908) I have mated a male Japanese turtle with a female hybrid between the Japanese turtle and a ring-dove. Each time fertility has been equal to development and hatching in the height of the season; then perhaps a few eggs were fertilized, but this gradually fell short, until no sign of beginning development could be seen. *This means that the season of greatest vigor of the birds is the season of highest fertility.*

Infertility may often be found associated with "weakness." Birds in the first breeding season do not do as well as when they are 3 or 4 years old; only then do they come to fullest maturity, and they then have all their surplus energy for reproduction.

Just as energy gives fertility, so it carries development to different heights, *e.g.*, males above females.²⁰ Birds of resplendent plumage or increased number of feathers (fantail, Japanese cock, peacock, etc.), are birds that have attained greater and greater developmental energy. In the same way those *tissues of greatest energy* carry the number of parts, and differentiation, to the highest points.

Problems of evolution are to be slowly approached through observation, experiment, reflection, and theory. Their solution will tax the resources of the laboratories in every department of biology, indeed of every department of science; and

¹⁹ This author has since called attention to the fact that in still some other orders of birds a majority of hybrids are males.—EDITOR.

²⁰ "The coexistence of the sexes is known in a number of instances. Nansen showed that *Myxine glutinosa* is a male until 32 cm. long, and thereafter produces ova. In some cases only male cells are produced. This does not look like sex-determination by a special chromosome. Schultze, working with *Microstoma*, showed that in rare cases, when fission begins, the anterior zoöid is male, the posterior female. Ishikawa (1891) showed that in the shrimp *Gebia* the gonad has anterior testicular and posterior ovarian parts." (XZ 4)

not the laboratories alone, but the laboratories reinforced and supplemented by every method of research in the study of *living organisms*.

There is no one highway to solution. We can not circumvent it by curves of probability. The philosophy of chance is wholly superficial. The more we know the less room there will be for chance. It is our business to eliminate chance by tracing the *history* of the elements supposed to obey chance.

In studies on evolution our material, first of all, must be selected with a view to eliminating chance. We must work with *pure species*—that is, with wild species rather than domestic mix-ups. Purity in species means that we can know something about our subject. Some wild species are mix-ups; they can not be our main dependence. Their behavior must be judged by that of better known forms.

Variation is not chance, and fluctuation is a thing to be studied. The more we lump things and hide details the more we get lost in the wilderness of chance.

CHAPTER XV.

DESCRIPTIVE AND HISTORICAL ON THE SYSTEMATIC POSITION OF CERTAIN RING-DOVES.¹

The genus *Turtur* is broken up by Salvadori² into the subgenera *Turtur*, *Homopelia*, *Streptopelia* (collared turtles), *Spilopelia*, and *Stigmatopelia*. Salvadori, however, continued the use of *Turtur* as the generic name of all the species included in the five groups. I have preferred to treat them as five genera.

THE BLOND RING-DOVE (*STREPTOPELIA RISORIA*).

Salvadori does not regard this bird, more often known as *Turtur risorius*, as a distinct species, for he says (footnote, p. 414): "It is uncertain to which species the tame dove belongs," and gives in the same footnote the synonymy which applies to it.

Thirteen species are named under the subgenus *Streptopelia*, and *T. risorius* is supposed to belong to one of these, but which one is not even suggested. In the long list of synonyms I see that the bird has been named as follows:

- Linnaeus, *Columba risoria* (S. N. I, p. 285, N. 33) in 1766.
Buffon, *Tourterelle à collier* (Hist. Nat. Ois., II, p. 550) in 1771.
Latham, *Collared turtle* (Syn., II., 2, p. 648, W. 42) in 1783.
Selby, *Turtur risorius* (Nat. Libr., Pigeons, p. 170) in 1835.
Bonaparte, *Streptopelia risoria* (Consp. Av., II., p. 65) in 1854.

In a further footnote (p. 415) Salvadori remarks: "This bird has become very common everywhere in a domesticated state." His description of this dove (same footnote) is as follows:

"*Adult male*.—Upper parts yellowish bay or isabelline, greyer on the outer wing-coverts and secondaries; a broad black collar, edged above with whitish grey, on the hind neck; throat almost pure white; breast pale isabelline, changing into white on the abdomen, vent, and under tail-coverts; sides pale grey; under wing-coverts pale grey, almost white; primaries pale brown; central tail-feathers isabelline grey, the lateral ones darkish grey, changing into white toward the tips; outer web of the outer tail-feather almost white; tail below blackish at the base, the black sharply defined from the apical half, which is white, but tinged with grey near the black part; bill light horn; irides orange, feet pink-red. Total length about 10 inches, wing 6, tail 4.5, bill 0.6, tarsus 0.85.

"*Female*.—Similar to the male, only somewhat smaller."

The white ring-dove is regarded by this author as a variety of *T. risorius*.

Salvadori notes that the following hybrids of the blond ring-dove have been obtained:

1. *Ectopistes migratorius* ♂ × *T. risorius* ♀ (Mitch., P.Z.S., 1849).
2. *C. livia* var. *laticauda* ♂ × *T. risorius* ♀ (Dr. Günther).

The range of *Streptopelia* is given by Salvadori, but he says nothing about that of *T. risorius*. The range of the subgenus *Streptopelia* is: "Africa, S. W. Palæarctic

¹ The inclusion of the materials of this chapter in the present volume seems advisable for the following reasons: (1) The "collared" ring-doves have been very extensively used in the breeding data with which the volume chiefly deals. (2) The names of these doves are considerably confused in the literature. (3) The specific value of the blond rings and white ring-doves, which are treated in this volume as species, has not been conceded by most writers. (4) It seems necessary to present Professor Whitman's conclusions on these matters, and to publish what he has added toward an adequate description of these forms. (5) Much of the literature touching these matters is so little available to most of those biologists who will make use of this volume that the extensive quotations herein contained seems warranted.—EDITOR.

² Catalogue of Birds in the British Museum, Vol. XXI, 1893.

Region, Indian and Oriental Regions, Indo-Malay Archipelago, and also Marianne or Ladrone Islands."

Brisson³ on the collared turtle (*La Tourterelle à Collier*).—The blond ring-dove was named *Turtur torquatus* by Brisson, and described as follows:

"*Columba superne ex alba rufescens, inferne alba; collo inferiore et pectore albis ad vinaceum tendentibus; collo superiore torque nigro cincto. Turtur torquatus.*

These common and scientific names were further noted:

Turtur Indicus Aldrovandi. *Avi.*, t. II, p. 508, 1645.

Columba Turtur Indica Aldrovandi. *Klein. Avi.*, p. 119, No. 13, 1750.

Turtur Indicus Aldrovandi. Willughby. *Ornithologie*, p. 134, 1670.

Turtur Turcicus Schwenckfeld, *Avi. Sil.*, p. 364, 1603.

Tourterelle des Indes Albin. *Hist. Nat. Oiseaux*, t. III, p. 19, 1750.

The Germans are stated to call it *Turckisch-Teublin*; Schwenckfeld calls it *Indianisch-Teublin*; Frisch uses *Lach-Taube*. The Silesians know it as *Lachendes-Teublin*; the English as *Indian turtle*; and Willughby calls it the *turtle-dove* from the East Indies. Brisson gives the following description:

"It is a little larger than the preceding (*Turtur turtur*). Its length from the tip of the beak to the end of the tail is one foot; to the end of the toes, nine inches. The beak, from the tip to the angle of the mouth, is ten lines in length; the tail, four inches and three lines, the tarsus (pied) ten lines; the middle of the three anterior toes, including the nail, thirteen lines; the lateral toes are a little shorter, and the hind toe is shortest of all. Wing expanse is one foot and eight inches. The wings, when closed, extend a little beyond half the length of the tail. The upper parts of the head and neck, the back and the wing coverts are reddish, or a light color verging to reddish. The under front part of the neck and the breast are light with a slight vinous tinge. The abdomen, the sides, the legs, and the lower coverts of the tail are white.⁴ The rump inclines a little to brownish-grey. The flights are of the same color with the outer border whitish. The tail-feathers are ashy-grey above, and all except the two middle ones are tipped with white; below, they are blackish at the base, then of a light grey, passing into white at the tip, the outer one at each side having its outer web white. The upper (hind) part of the neck bears a black collar of about two lines in width. The iris of the eyes is of a beautiful red; the beak is blackish; the feet red, and the nails yellowish green.

"The female is distinguished from the male by its paler color.

"A variety of this species is the Turtle Mule, *Turtur hybridus* (Brisson), or *Turtur mixtus*, Schwenckfeld. This Turtle Mule is called *Zwitter Turtel-Taube* by the Germans.

"It is of the same size as the Collared Turtle. The top of the head, the neck, and the breast are of a vinous color. The back is wholly ashy and without spots, but a light tinge of obscure reddish is perceptible. The abdomen, the under side of the wings, and the end of the tail is of the same color as the Collared Turtle. The flights are dark, the feet blood-red, and the beak bluish-brown.

"This variety arises from the union of a male Common Turtle and a female Collared Turtle."

Brisson makes no statement as to the place of origin of the "blond dove"; but, as all the authors cited by him seem to follow Aldrovandi in ascribing to the bird an Indian origin, Brisson's silence may be construed as acquiescence in this view.⁵

Temminck on the blond ring-dove.—In his "*Histoire Naturelle Generale des Pigeons*" Temminck⁶ calls this bird the "blond dove" (*Columbe blonde*), and adopts the systematic name given by Linnæus, viz, *Columba risoria*, although he ascribes it to Latham. Synonyms, *Columbe blonde*, *Columba risoria* Lath., are given in the index (pp. 481, 482). His account follows.

³ *Ornithologie*, Vol. I, Paris, 1760.

⁴ White here means light-colored, i.e., pale or whitish-gray.

⁵ Recently W. Kobelt ("*Die Verbreitung der Tierwelt*," Leipzig, 1902, p. 80) has given the following opinion "Die Heimat der echten Lachtaube, von der unsere zahmen Exemplare stammen, ist Ostafrika; nach Deutschland verfliegt sie sich äusserst selten einmal." In this statement Kobelt probably depends on Brehm.

⁶ Vol. I, 1813, pp. 323-332.

"We cannot well understand the reasons which led Buffon to regard the Collared Dove (*Columbe à collier*) as a second race, or a constant variety, within the species of our common Turtle;⁷ and still less how this celebrated naturalist could assert that this dove is found in our clime. However, it is uncertain that these pigeons do not form a race or constant variety of our common Turtle,⁷ since it is with some difficulty that we succeed in getting hybrids (*métis*) by crossing these species—hybrids which are obtained only through the skilled care of man, and which nature never would have been able to produce. Moreover, the common Turtle is native to our clime, while the other is only kept in cages, where it reproduces under the care which we are accustomed to bestow upon it.

"The species which forms the subject of this article has, then, been imported from warm countries, as indicated by its sensitiveness to cold even now, after a domestication which seems already quite ancient. We recognize this bird, unmistakably, in the description which Brisson gives of the 'Collared Turtle of Senegal,' a species which Buffon incorrectly identifies with his 'Tourterelle du Senegal' (colored plate, No. 160). We have already spoken of this error of Buffon in the article on the *Emerald Dove* (*Colombe Émeraudine*). A modern naturalist,⁸ to whom natural history is already indebted for several interesting discoveries, has found the species here under consideration living in full freedom and breeding in a wild state in the midst of the ancient forests of southern Africa. Thunberg⁹ has found this Collared Turtle in all the southern countries of Africa. It delights especially in places covered with bushes. This bird, he says, never changes place without laughing afterwards, and on this account has received the specific name, *risoria*. Its laugh and its hou-hou make known its place of retreat. Its flesh broiled is quite dry.

"Taking these facts in connection with the domestic state in which this pigeon is found everywhere else, we may assume that the species is native to Africa, and consider the bird described by Brisson, under the name *Tourterelle à Collier du Sénégal*,¹⁰ as well as that described by Le Vaillant, in pl. 268, as the type of our Collared Turtle.

"Sonnini informs us that he has seen Collared Turtles in Egypt, where the inhabitants are very fond of them, and take special care of them. We do not know whether this author has seen the species at liberty, or reduced to a state of domesticity, as it is with us.

"As the name 'Collared Dove' would apply to several other species, which have the collar on the back of the neck, we prefer to follow the example of Le Vaillant and adopt the name 'Blond Dove' as the more proper one for this species.

"Le Vaillant has met with Blond Doves only on the borders of the Great Namaqualand. They are smaller than those we rear in domesticity, but their cooing is absolutely the same. They nest in trees, build a flat nest like those which our Turtles construct, and lay two wholly white eggs.

"This species measures in length ten and one-half inches; the wings in repose, six inches and three lines. The whole plumage is of a pretty pearl gray, shaded with a delicate purplish tint, whitening on the forehead and the lower parts, and taking an isabelline fawn-color on the back and wings. The remiges are dark, bordered with fawn. The feathers of the tail are ashy above, and all, except the two middle ones, tipped with white; the external one of each side has its outer web white. The upper part of the neck is encircled with a black collar about two lines in width; the bill is blackish, the iris and the feet are red.

"The female differs little from the male, except that its collar is narrower, and the breast has a clearer color.

"The male is very fond of his mate; he usually keeps near her, especially during the night, and tries to show her his love through notes that bear some resemblance to a

⁷ *Turtur turtur*.

⁸ Probably Le Vaillant (see his Introduction, pp. 11-12.)

⁹ *Voyages au Japon par le Cap de Bonne Espérance*, Tom. I, p. 330.

¹⁰ This bird was *Turtur vinaceus* according to Salvadori (synonyms), Catalogue of Birds, XXI, p. 428.

burst of laughter. He gives besides, a plaintive note, but one which is not disagreeable and which may be rendered by the syllables *kukuruku*.

"The Blond Dove, like many other birds, is liable to take a wholly white color. In this condition it would be easy to confound the species with the true White Dove, which is always of this color; but it will suffice to say here that, without taking note of the size or form of these birds, which differ considerably, it is nevertheless easy to distinguish the White Blond Dove. In addition to the facts that the whole mantle and the wing-coverts always preserve in this bird a delicate isabelline tint, and the proximal parts of the tail feathers are of a more grayish tone, it is still further distinguished by small feathers which form the collar, these always being shaded towards the tip with a tint less white."

As the collared turtle of Senegal, figured and described by Brisson, has been pointed out by Temminck in the above-quoted remarks as the "type" of the blond dove, Brisson's¹¹ description is here given in full:

"*La Tourterelle à Collier du Sénégal—Turtur torquatus senegalensis*.¹² *Columba superne griseofusca, inferne sordide alba; remigibus fuscis, oris exterioribus sordide albicantibus; collo superiore torque nigro cincto.*

"It is nearly of the size of the merle. Its length, from the tip of the beak to the end of the tail, is nine inches and six lines; to the end of the toe-nails, seven inches and eight lines. The beak, from the tip to the angle of the mouth, is nine lines long; the tail, three inches; the tarsus (pied) nine lines; the middle of the three anterior toes including the nail, ten lines; the lateral toes are a little shorter, and the hind toe still more so. The wings closed extend to about half the length the tail. The head, the neck and the breast incline to a vinous color, slightly browner on the upper parts of the head and neck. The back, rump, upper tail-coverts, and wing-coverts, are grayish-brown. The abdomen, the sides, the legs, and the lower coverts of the tail are of a dirty white. The under wing-coverts are ashy. The flights, primaries as well as secondaries, are blackish-brown with whitish edges (blanc sale). The two central tail-feathers are grayish-brown, and the lateral ones are black for about two-thirds their length, then gray to the end; the outer web of the outer feathers of each side, also gray. The upper part of the neck bears a black collar about three lines in width. On the sides of the neck this collar ascends a little towards the head.¹³ The beak is blackish, feet red, nails brown. It is found in Senegal, from which country it was sent to Réaumur by Adanson."

The uncolored figure of this pigeon, given by Brisson (drawn and engraved by Martinet, probably from a mounted skin), is too characterless a picture to serve for identification. The shape and proportions of the head and beak would never suggest close affinity with the common blond dove. The description, although inadequate, when supplemented by the observations of Le Vaillant and Thunberg on the voice and the behavior (as reported by Temminck), certainly seems to support Temminck's identification of it as the common blond ring. The habit of giving a laughing coo after every change of position is so characteristic of the blond ring-dove that it may be taken as very reliable evidence of close consanguinity. Brisson offers no suggestion on this point. The black streak in front of the eye is an obstacle, however, to identifying it with *St. risoria*. The light edges of the quills is a much less important distinction, as it applies to many species, and varies much even within the same species. The Japanese ring-dove, so far as form, size, and color are concerned, might be the real wild species of *St. risoria*; but its voice differentiates it and makes identification impossible.

¹¹ Brisson, *Ornithologie*, vol. 1, 1760, pp. 124-125, pl. xi, fig. 1.

¹² We think this may, or may not, be the *Turtur vinaceus* as listed by Salvadori (p. 428).

¹³ This is a peculiarity unknown in any other turtle-dove and possibly the appearance here noted was due feathers pulled out of place in the specimen described.

The black streak in front of the eyes is not mentioned by Brisson or by Temminck. Possibly the *Turtur torquatus senegalensis* of Brisson is not the *T. vinaceus* of Salvadori.

Linne¹⁴ on *Columba risoria* (collared turtle).—

"Brown, beneath grey-claret: crown grey; black crescent on the neck above (behind), spotted (bordered) with white; lateral tail feathers black, spotted (tipped) with white. Inhabits Europe and India; larger than the Turtle-dove (*T. turtur*). Bill blackish; irides red; body beneath white; rump and quill feathers¹⁵ grey-brown; tail cinereous, the lateral feathers tipped with white."

Buffon.¹⁶—The blond ring-dove was regarded by Buffon as a race or a variety of the type represented in the common turtle of Europe (*Turtur turtur*).

"In the species of the turtle, we recognize two races or constant varieties: the first is the 'common turtle,' the second is called the 'collared turtle,' because it bears upon the neck a sort of black collar. Both are found in our clime, and when mated together they produce a hybrid. The one described by Schwenckfeld, which he calls *Turtur mixtus*,¹⁷ came from a male common turtle and a female collared turtle, and took after the mother more than the father. I do not doubt that these hybrids are fertile, and that they return to the race of the mother in the course of some generations."

Selby¹⁸ on the collared turtle (*Turtur risorius*).—The following synonymy references and descriptions are given by Selby:

"*Columba risoria*, Auct.; *Turtur torquatus Senegalensis*, Briss., I, p. 124, t. II, f. I; Columbe blonde, Temm., Fig., I, p. 323; Tourterelle à collier, Buff., Pl. Enl., No. 244; Boitard et Corbié, Monon. des Pigeons, p. 236, pl. 25.

"From a very remote period this species appears to have been domesticated, or rather kept in that state of captivity in which it is retained at the present day; for there is every reason to suppose that the turtle-dove adverted to in Holy Writ may be referred to the same bird, as it is still abundant in Egypt and other parts of the East, where it is fostered and cultivated with care, and it is certain that many of the representations in the works of ancient art, where the dove figures as the emblem of tenderness and affection, or where it is depicted as the appropriate attendant of Venus, are accurate delineations of the collared or domestic turtle.

"This bird does not appear to be susceptible of that attachment to its home or place of birth for which the common or dove-cote pigeon is remarkable, and which peculiar quality renders that species so serviceable to man. On the contrary, like its congener the common or wild European turtle (*Turtur communis*),¹⁹ it can not be left to range at perfect liberty without the danger of its flying away to return no more, and must therefore be kept constantly confined either in cages or in aviaries adapted for that purpose. In this state of captivity, if properly attended to, it breeds with facility, sometimes producing as many as 8 broods within the year; but, being a native of warm climates, and very impatient of cold, it is seldom cultivated to the same extent in this country as it is in those where the temperature is better adapted to its constitution. The male shows great tenderness and affection to his mate, and is constantly by her side, soothing her with caresses or paying court by soft cooing notes, and that peculiar cry so expressive of laughter, and from which it takes its specific name.

"In its wild or natural state it is found in various parts of Africa, and we have by us specimens from the southern part of that continent, a description of which, as varying in depth and intensity of color from the domestic variety, is here subjoined.²⁰

¹⁴ Syst. Nat. (translation by Turton of last edition by Gmelin, London, 1806, p. 478).

¹⁵ These feathers in *T. vinaceus*, according to Linne (p. 474) are "edged with whitish." Brisson describes the edges of the same feathers as "blanc sale"; Selby (p. 172) as "greyish-white." Salvadori (p. 429) says, "All the quills with narrow light edges." Reichenbach (Tauben, 1862, p. 741) says the chief distinguishing mark is "die auffallend weissen Säume der Schwingen." This character, as described by most authors, would not stand in the way of Temminck's view that this species represents the type of *T. risorius*. The "streak of black" in front of the eye, however forbids this identification.

¹⁶ Hist. Nat. Ois., II, p. 550, 1771.

¹⁷ Theriotrop. Sil., p. 365.

¹⁸ P. J. Selby, The Nat. Hist. of Pigeons, Vol. V of the Naturalists Library, Edinburgh, 1835.

¹⁹ That is, *Turtur turtur*.

²⁰ This was probably *St. vinaceus*.

"The length is about 10 inches. The chin is whitish; from the corners of the mouth to the eyes, is a narrow streak of black.²¹ The cheeks, neck, breast, and belly gray tinged with vinaceous or pale purplish-red; the hind neck with a demi-collar of black, some of the side-feathers composing it being tipped with white. The back, scapulars, and rump are of a pale clove-brown, with a greenish tinge. The margins of the wings, the greater coverts, and under wing-coverts are blue-gray. The greater quills are hair-brown, delicately edged with grayish white. The tail is slightly rounded, the two middle feathers entirely clove-brown, the remainder on each with the basal half black, the tips bluish-gray, except those of the two outermost, which are white. The vent and under tail-coverts are white, the legs and feet gray (?); the inner toe a little longer than the outer. In its natural state it inhabits the woods, where it breeds, making a nest similar to that of the common turtle, and lays 2 white eggs. It seeks its food in the open grounds, and subsists upon grain, grass-seeds, pulse, etc. It is easily distinguished, and the place of its retreat soon discovered by its cooing notes, one of which we have already stated to resemble the human laugh.

"A mixed breed is sometimes obtained between this species and the common wild turtle, but the progeny are invariably mules, and incapable of further increase, a fact that has been established by many careful and oft-repeated experiments, and one which affords a strong argument against the supposition that many of the varieties of the common pigeon, or of the domestic fowl, are the result of a mixture of different species.

"Besides the wild turtle known to us as a regular summer visitant in the southern districts of England, the *Columba maculicollis* and the *Columba aurita* of Temminck and several others belong to the group, of which the present species may be considered a type."

More recent authors by no means agree in the use of common names for this ring-dove. Mr. F. Finn,²² of the Indian Museum, Calcutta, calls the ring-dove the "domestic turtle-dove." Of the domestic ring-dove he says: "It is certainly not identical with the wild *Turtur risorius*,²³ so far as the note goes; this being a very marked point of specific difference in all the ring-necked species of *Turtur* I have seen alive." Salvadori uses the name "tame turtle-dove." Stejneger uses "ring-dove" for the domestic bird; "ringed turtle-dove" for the wild species of China and Japan. I think "turtle-dove" may be reserved for all the true turtle-doves having two side-spots on the neck, and "ring-doves" for all doves with a half-collar. "Turtle-dove" for "ring-dove" leads to confounding the latter with the turtle-dove. The common cage ring-dove, *St. risoria*, I call the blond ring-dove. (H 6, W 10)

THE WHITE RING-DOVE (*STREPTOPELIA ALBA*).

Temminck.—A short chapter by Temminck²⁴ is devoted to the white ring-dove, which he regards as a distinct species, and to which he gives the name *Columba alba*. The chapter follows in translation:

"*Columba blanche, Co'umba alba, Mihi*.²⁵

"We give to this well characterized species the name White Dove, because, in fact, it is always and wholly of this color. It is surprising that this little dove has always been confounded with the Blond Dove, which is liable to have a white plumage. We have already spoken of this variety; but it seems necessary to repeat in this chapter the remark, that the White Blond Doves are distinguished at first sight in this, that the mantle, the wing-coverts, the rump, and the two middle feathers of the tail, always preserve a slight isabelline tint, and that the proximal part of the tail is of a more grayish tone. They are further distinguished by the more sombre color of the small feathers which form the collar. If we take

²¹ This is a mark never found in *St. risoria*.

²² "The Cage-Birds of Calcutta." The Ibis, 8th ser., Vol. I, No. 3, 1901.

²³ I suppose Finn here means *T. douraca*.

²⁴ Vol. I, 1813, pp. 333-335.

²⁵ This dove was named *C. veneris* by Boitard and Corbié (p. 237, 1824) and regarded as a variety of *Turtur risorius*. See their statement in the pages which follow.

no account of these differences which are found only in the more or less bright colors of the plumage, and which are liable to vary in different individuals, it will still be easy to recognize the species here considered.

"The White Dove is smaller than the Blond Dove; it is an inch less in total length, and its tail is shorter. Its wings, longer in proportion, reach back three-fourths of the length of the tail, while the wings of the Blond Dove end at about the middle of the tail, which in this species is lengthened and more tapered. Finally, the White Dove has a milk-white plumage throughout, the feet are rose-red, the iris is red, and the bill is dusky red.

"Sonnini has represented in his plate 67, fig. 1, our Blond Dove, and in fig. 2 the White Dove. The characteristics in respect to form, which serve to distinguish these two pigeons, are there perfectly portrayed. The White Dove appears to be a native to China. It is often found represented on papers and tapestries made in that country.

"Dufresne, of the Museum of Natural History, has shown us two very exact pictures of these birds in two different collections of original designs painted by the Chinese. In our climate the species is reduced to domesticity; these birds are seen only in cages. They are very sensitive to cold, which they seem to endure less easily than the Blond Doves."

Boitard and Corbié.—In a classical monograph of the pigeons, entitled "*Les Pigeons de Volière et de Columbier*" (1824), these authors²⁶ give brief accounts of both blond and white ring-doves, adopting the name *tourterelle à collier* for the one and for the other inventing the new name "dove of Venus" (*Columba veneris*). These authors regard the white dove as a variety of the blond dove, and herein disagree with Temminck. They give several points of interest in the natural history of these doves and to some extent supplement Temminck's account. Their words are:

"*Tourterelle à Collier; Columba risoria, Lath. La Tourterelle à Collier, Buffon, Pl. Enlum. No. 244. La Tourterelle grise des marchands, et la Tourterelle blonde.*

"It is a little larger than the preceding (European Turtle); pale reddish in the upper parts, with a slight vinous tint on the breast and front side of the neck; whitish below. Feathers of the wing brownish-grey, bordered with a paler color; those of the tail ashy and tipped with white, with exception of the two middle feathers; with a narrow black collar on the back of the neck. Bill grayish, darker towards the point. Iris and feet red. The collar appears in the young only after the first moult.

"This species and the following variety are those so commonly reared in cages and aviaries, where, excepting the time of moult, they breed regularly every month, if care is taken to keep them in a warm place. The cooing of these birds is so wearisome and annoying that, despite the great facility with which they become tame, despite the grace of their form and the gentleness of their manners, one easily tires of them, if they are not kept confined in a place set apart.

"In Egypt they are very common, and it seems that through special care, the inhabitants have succeeded in attaching them to their aviaries, which they never abandon, although left free to go out and fly about the fields.

"The Collared Turtle is found in a state of nature in the Indies, Barbary, Senegal, and perhaps all Africa. As we have said, one easily succeeds in crossing it with the Wood Turtle (*Turtur turtur*), but the hybrids thus produced are infertile and cannot therefore reproduce their variety, or form a race, as supposed by Buffon.²⁷

²⁶ Pages 236, 237.

²⁷ Buffon (*Hist. Nat. Ois.*, I, p. 551, 1771) says: "Je ne doute pas que ces métis ne soient féconds, et qu'ils ne remontent à la race de la mère (collared turtle) dans la suite des générations."

"Schwenckfeld has described one of these mules under the name *Turtur mixtus*,²⁸ produced from a male Common Turtle and a female Collared turtle.²⁹ These birds are seldom reared except for the charm of their plumage, although the young are easily fattened and their flesh is quite tender.

" . . . Temminck makes a separate species of this bird (the White Turtle, *C. veneris*) which he calls the White Blond Turtle³⁰ but other naturalists regard it only as a constant variety or race of the preceding species; and this seems to us all the more probable, as the offspring which it produces with that species are always fertile, while those which it produced with the Wood Turtle are always mules.

"I have given this charming variety the name, 'Dove of Venus', because it is usually with these birds that painters and poets represent the mother of love. This Turtle is a little smaller than the preceding. Its plumage is white; the collar is wanting, but it is indicated on the back of the neck by feathers more rigid than the others, and of a little duller white. This bird is more delicate than the preceding and requires greater care and especially more heat. Its habits and manners are precisely the same.

"It is easily mated with the Collared Turtle; but the young that are raised vary but little in plumage. They are almost always exactly like the Collared Turtle, or the White Turtle, and in the latter case they never have a black collar. This is a peculiarity which never occurs in the pigeons, the young of which may take after the father and the mother, while in the Turtles they are always wholly one or wholly the other, although we may find in the same brood one white and one gray." (H 6)

I find the pure white ring-dove (*St. alba*) is distinguished from the blond ring-dove (*St. risoria*) in the following ways: (1) it is pure white; (2) it is smaller than the blond ring and has a shorter tail; (3) the young are hatched quite naked, *i.e.*, they have almost no "down"; (4) the voice is quite distinct, though evidently of

²⁸ Schwenckfeld. *Avi. Sil. Therio-tropheum Silesiæ*, etc., 1603. (Buffon, *loc. cit.* p. 551, also cites this case).

²⁹ In the chapter devoted to the common turtle of Europe (*Turtur turtur*) Boitard and Corbié have the following to say of the cross between it and the ring-dove:

"It may be mated with the Collared Turtle and even with the White Turtle; but the offspring resulting are sterile—at least only such have hitherto been obtained. The hybrids mate among themselves, or with the Collared Turtle, or with the Wood Turtle; they caress each other with the same ardor, lay and cover their eggs with the same sollicitude, and yet these eggs never hatch—without doubt the fault of the germ. This experiment, made by Manduyt, by Vieillot, and with a sort of stubborn persistency by my collaborator, Mr. Corbié, has always had the same result."

Manduyt relates his experience in crossing in the *Encyclopedie Methodique*, 1784, p. 482. Speaking of the Common, or Wood Turtle, as he called it, he says: "It will breed equally well, whether crossed with the Collared Turtle, as Schwenckfeld has done, or with the White Turtle, as I have done; but so far from the trial which I have made tending to prove that the hybrids arising from these crosses are fertile, they furnish no proof, but evidence to the contrary.

"Having inclosed a male wood Turtle and a White Turtle (*Turtur alba*) in the same aviary, the two birds soon mated; the female laid, the eggs hatched, the young resembled the father more than the mother, the plumage of the latter only having lightened up that of the male, without destroying the imprint of the half collar borne by the father on each side of the neck. The hybrids were of a very agreeable shade of light grey (gris-blanc). There were several sets of eggs from these birds, all developed successfully, and all the young were raised. They were partly males, partly females, as was evident from the fact that some had much stronger voices than the rest. The positive proof that some were females was furnished by their laying eggs. I separated them, and made sure after sufficient time that those which I regarded as males did not lay. I kept a male and a female inclosed for more than a year without their having mated, and yet the female laid twice, two eggs each time, without making any nest, and without taking any care of the eggs, which she allowed to escape wherever she happened to feel the need of getting rid of them. I inclosed this same female with the male by which she was sired, and which was eager to mate. They passed a summer together in the same aviary, the male kept up his addresses to the female unceasingly, but she never responded to his desires, or to any of his caresses, but appeared absolutely indifferent to them; and yet she laid several times, as when she was inclosed with a male hybrid, and always without taking any care of her eggs, which I found several times in the vessel which served to hold the drinking water for the pair kept in captivity.

"I removed the first female and gave to the same male another, likewise a hybrid: the result of the experiment was the same. These hybrids, then, were not fertile *inter se*, nor were the females fertile with the male parent; but it would be necessary to repeat the test upon a much larger number of individuals in order to be able to decide."

³⁰ An error. Temminck gave this name to *albinos* of the blond turtle, and regarded the white turtle as a pure breed or species.

the same general character; (5) the ring is cream-colored, just distinguishable from the general white of the rest of the body; (6) the white rings always prefer their own kind to the blond rings in mating, and the latter also prefer their own kind; (7) in crossing, the young tend strongly to preserve the original colors, either brown or white. It is true that the incubation periods of their eggs is the same, and further that most of their habits are quite similar. The white rings are less resistant to trying conditions and probably have a shorter term of life.

The general color of the blond ring (*St. risoria*) could be described as a pale fawn or isabelline, which becomes lighter on the throat, and fades out towards and around the vent, passing imperceptibly into the white of the under tail-coverts.

The black ring or collar is sometimes narrower at its middle on the back of the neck than at the ends. This fact, together with the complete interruption of the ring on the back of the neck in the first plumage, by which it is broken into two portions, one on each side of the neck, beginning a little below and behind the ear-coverts and growing narrower backward, suggests that the half ring has arisen by the extension of two spots like those seen in the mourning-dove. This ring is creamy white in the white ring. It is often reduced to a mere shadow, or wholly absent, in the first plumage.

THE JAPANESE RING-DOVE (*STREPTOPELIA DOURACA*).

This bird is not *St. risoria*, although it looks like it; it has a different voice, never laughs, coos rarely, lays sparingly, is larger than *St. risoria*, and is somewhat darker. These facts I have been able to learn definitely from keeping and breeding in confinement 24 birds received from Japan.³¹

Stejneger³² gives this dove the name *Turtur douraca torquatus* (ringed turtle-dove = Shirako-bato). Hodgson³³ is responsible for the name *douraca*, a name which Stejneger thinks should be reserved for the wild ring-dove of India; and Bogdanow³⁴ is held responsible for *torquatus*, since Brisson had before (1760) given this name to the common tame ring-dove.

Stejneger is responsible for using *both names* as a means of separating the Chinese and Japanese birds (*torquatus*) from the Indian type (*douraca*).

Stejneger says Schlegel (Mus. P. Bas, Columb., p. 123, 1873) made it clear that the tame bird is not a descendent of the wild ring-dove of India, China, or Japan.

Stejneger insists that the Indian species is distinct, as the outer web of the outer tail-feathers in *T. risorius* is white, while it is blackish in *T. douraca*. The Indian bird is, moreover, darker (drab).

If this species is distinct from the wild Indian ring-dove, as Bogdanow and Stejneger claim, then I should prefer *Turtur torquatus* to the trinomial proposed by Stejneger. Schlegel also (see Stejneger, *loc. cit.*, p. 427) calls attention to the racial difference between the Indian species (*douraca*) and the form found in China and Japan. This difference is thus stated by Stejneger (p. 427):

"My Japanese specimens, as well as a number of Corean examples, which Mr. Jouy kindly allowed me to examine, have the color of the back nearly that of Ridgway's 'Isabella

³¹ Through the kindness of Professor Ijima.

³² Proc. U. S. Nat. Mus., June, 1887, p. 426.

³³ Gray's Zool. Misc., p. 85.

³⁴ Tr. Sib. Obsch. Jestestv., XII, p. 98, 1881.

color' (Nomencl. Colors, pl. III, No. 23), while the Indian bird has the back duller and darker, or like his 'drab' (pl. III, No. 18). The latter, which is the true *T. douraca*, seems also to be somewhat smaller."

This difference in color seems to me of doubtful value as a basis for distinguishing species, since in the ring-doves, as in the turtle-doves proper, and indeed in most if not all species of pigeons, we meet with a similar difference—the "lighter" and the "darker" shades often quite marked.

The difference in "size," based on a single Indian bird skin, is of no value, unless it be shown to be general. Salvadori (*loc. cit.*, p. 432) gives the following measurements of *T. douraca* (including Chinese and Japanese forms): Total length 11.9 in.; wing 6.8 in.; tail 5; bill 1.6; tarsus 0.9. The wing measurement is 172 mm. (6.8 in.) Stejneger's specimen of *T. douraca* measured only 160 mm.—evidently an unusually small bird, or a poorly preserved skin.³⁵

Stejneger points out as a striking constant distinction between *T. risorius* and *T. douraca*, that the outer web of the outer tail-feathers in *T. risorius* is "entirely white," while in *T. douraca* it is "blackish." Further, the tail is longer in the latter.

I find this color distinction is overdrawn. Examining two female *St. risoria*, I find that in neither case is the web "entirely white."

Comparing these with a female Japanese ring-dove, I find that in the latter the outer web starts at the base as a *light pearl gray*, *lighter* (more whitish) *at the outer edge*, becomes gradually darker gray until, at about the middle, the blackish appears (the edge continuing whitish) and continues for about 32 mm., or for about the third quarter of the entire feather-length, lightening up into paler and paler gray towards the tip.

In the first *St. risoria* female I find as follows: The outer web starts at the base as a light pearl-gray—lighter at the outer edge—and darkens into a clear gray, which for the first third of the length is not distinguishable from that of the above Japanese bird; but towards the middle the gray becomes paler (just where the blackish prevails in the Japanese) and becomes pure white only in the terminal fifth.

The second *St. risoria* differs from the first in having the gray a shade paler and the light edge wider. But the edge is not pure white, and it shades into the gray of the mesial half. The real distinction, then, is that the Japanese ring has black in a portion of the outer web—*i.e.*, has a darker web as a whole³⁶—but the inner web also has a larger and deeper extent of black. This greater amount of black in the tail is correlated with the darker color of the Japanese bird as a whole.

The midrib, curiously, is decidedly darker in *St. risoria* than in the Japanese bird. The tail-feathers are from 12 mm. to 18 mm. longer in the Japanese birds than in the blond rings.

In all three of the birds just compared the black is stronger and more sharply limited in the under side of the feathers than above. In the Japanese ring-dove it reaches nearer to the tip than in the blond rings, and is continued on the outer web beyond its limit on the inner web by at least 12 mm. The wing of the above-mentioned Japanese ring-dove measured 162 mm.

³⁵ Schlegel (*loc. cit.*) points out that *T. risorius* differs from *T. douraca* of India in having: (1) a shorter tail; (2) the outer web of the outermost tail feathers *white*; (3) a very decidedly different voice.

³⁶ Salvadori (p. 432) says of *T. douraca*: "Lateral tail-feathers leaden grey, fading gradually into white towards the tips." Notice that he says nothing of "blackish."

Stejneger's wing measurements of two Japanese ring-doves are 176 mm. for a male and 174 mm. for a female. For one female of the true Indian ring-dove, Stejneger found a wing-length of 160 mm. It will be seen that my Japanese ring with a wing of 162 mm. is nearly the same as Stejneger's Indian ring-dove. This shows that the Japanese birds certainly sometimes attain only the length given for *T. douraca*, and hence Stejneger's size distinction of the Japanese and Indian birds is probably of no value. I call the Japanese ring-doves *Streptopelia douraca*. (H 14)

RECENT DESCRIPTIONS OF RING-DOVES.

Mr. J. H. Newman³⁷ has recently undertaken to give the names and affinities of the ring-doves (which he calls "collared turtle-doves") of Asia, Burma, and India. The names considered are:

- decaocta* (given by) Frivaldsky, 1838, to the Balkan species.
- douraca*, Hodgson, 1844, to the Nepal or Indian species.
- xanthocyclus*, Newman, 1906, to the Burmese subspecies.
- torquatus*,³⁸ Bogdanow, 1881, to the Chinese and Japanese species.
- douraca torquatus*, Stejneger (1887), to Chinese and Japanese species.
- decaocta decaocta*, Newman (1906), to Balkan, or "the North-eastern" species.

Newman states that the Indian species has very generally been confounded with *T. risoria* and regarded as the "typical form." He claims that the "type" is represented in the "big north-eastern race," namely, that of the Balkans to Turkestan. The Balkan type differs from the Indian species in being "much larger; having a broader nuchal collar; in being more conspicuously edged above and below with white; more white on the outer tail-feathers; and in having the secondaries and their coverts a pale pearl gray."

Although these are all variable features, Mr. Newman thinks that taken together they differentiate the two forms.

The names introduced by Newman require consideration. In order to maintain the contention stated above, he makes use of trinomials for each of the three species as follows: For the Balkan species, *Turtur decaocta decaocta*; for the Indian species, *Turtur decaocta douraca*; for the Burmese species, *Turtur decaocta xanthocyclus* n. subsp. Mr. Newman introduces the name *xanthocyclus* for the Burmese variety or subspecies, and gets the other names from older writers.

In regard to the name of the Balkan (or Asiatic) species, it is noted that Von Othmar Reiser, in his "Avifauna of the Balkans" (1894), cites a work by Johann von Frivaldsky, entitled "Balkányi Termész. et tudományi Utazásról, Budan," (1838), in which is figured and described a dove of this species. Frivaldsky's work is little known and has usually been overlooked, but the name he gives—*Columba decaocta*—is the oldest one known for this species, as Linnæus's name, *C. risoria* (1766), refers to the domestic species.

Frivaldsky founded his name on the dove from the Balkan regions (The Balkans through Turkestan, as far as Yarkand). Hume, in "Stray Feathers" (1874, II, p. 519), evidently not knowing Frivaldsky's work, named the same species *Turtur stoliczkæ*.³⁹

³⁷ Avicultural Magazine, Vol. IV, No. 11, Sept. 1906.

³⁸ Bogdanow adopts the name from Brisson (Orn., I, p. 92). Stejneger (1887) rejects Brisson according to the A. O. U. code, and then makes Bogdanow responsible for the name, which he (Stejneger) applies to the Chinese-Japanese species to distinguish it from the Indian species, the true *T. douraca*. A remarkable respect with disrespect for priority.

³⁹ Mr. Dresser published these facts in Ibis, 1903, pp. 89, 90.

The Indian species is held to be a subspecies of the Balkan or Asiatic species (*T. decaocta*), and for this subspecies Newman proposes to use Hodgson's name "*douraca*," which was founded on a dove from Dhôurakha.⁴⁰ Hodgson's name, according to Salvadori, applies to all the ring-doves in Japan, China, Burma, India, and the Balkans, except *T. humilis* and its Indian relative *T. tranquebaricus*.

Newman states that the Burmese species (*xanthocyclus*) is easily distinguished by its "broad yellow bare rings round the eyes." He further claims, with Shelley, that *T. risorius* (Barbary dove) is derived from the "rose-grey turtle dove (*T. riseogriseus*) of North-eastern Africa."

At this date (September 1906) it seems that the number of species of ring-doves is not definitely settled. The following are fairly well determined: The common ring-dove (*St. risoria*) goes (in a group?—EDITOR) with the African species *St. riseogriseus*. The Balkan ring-dove (*St. decaocta*), Indian ring-dove (*St. douraca*), Oriental ring-dove (*St. torquatus*),⁴¹ and Chinese-Japanese make one group.

Thirteen species (besides *risoria*) are described by Salvadori (pp. 414-438). The additional ones noted here indicate 17 species for the genus *Streptopelia*. There are 14 species of gray to blond color, 1 species of white color,⁴² 2 species of red or ruddy color. (H 6)

⁴⁰ A place conjectured by Newman to be in Nepal, a country on the southern slope of the Himalaya system. Hodgson's specimens were from Nepal, according to Salvadori. (See Hodgson in Gray's Zool. Misc. p. 85, 1844.)

⁴¹ At this later date the author seems definitely to agree to the separation of the Indian and Japanese forms. Throughout this volume, however, the name *douraca* applies to the Japanese ring-doves.—EDITOR.

⁴² This statement, too, indicates that Professor Whitman regarded *St. alba* as a good species.—EDITOR. (W 10 and WW 2)

CHAPTER XVI.

INFLUENCE OF THE SPERMATOZOA OF PIGEONS ON RATE OF DEVELOPMENT OF THE EMBRYO.¹

Crosses of those species of pigeons which have unequal periods of incubation offer opportunities for the study of the separate influence of egg and sperm upon the rate of development of the embryo which they conjointly produce. In other words, such crosses give opportunity for the study of such a question as this: When a cross is made between a female pigeon of a species whose incubation period is 14 days and a male whose species requires 18 days, will the incubation period of an egg from such a pair be prolonged? If so, is the prolongation due to the influence of the male?

TABLE 178.—Normal incubation time of domestic pigeons.

PAIR I.—♂ common (1) × ♀ common (1), 1897.			
Eggs.	Laid.	Hatched	Incubation. ¹
A 1	5 ^h 15 ^m p.m. Feb. 28.....	10 ^h 08 ^m a.m. Mar. 20.....	19 das. 16 hrs. 53 m.
A 2	5 ^h 30 ^m p.m. Mar. 2.....	6 ^h 35 ^m a.m. Mar. 20.....	17 das. 13 hrs. 5 m.
C 1	5 ^h 00 ^m to 5 ^h 40 ^m p.m. Apr. 14..	3 ^h 20 ^m p.m. May 2.....	17 das. {21 hrs. 40 m. to 22 hrs. 20 m.
C 2	4 ^h 35 ^m p.m. Apr. 16.....	7 ^h 08 ^m a.m. May 3.....	16 das. 14 hrs. 33 m.
D 1	p.m. May 14.....	1 ^h 40 ^m p.m. June 2.....	18 das. 20 to 21 hrs.
D 2	p.m. May 16.....	6 ^h 20 ^m a.m. June 2.....	16 das. 13 to 14 hrs.
G 1	p.m. Aug 10.....	5 to 6 a.m. Aug. 29.....	18 das. 12 hrs., nearly.
G 2	p.m. Aug. 12.....	12 to 1 p.m. Aug. 29.....	16 das. 18 hrs., nearly.
PAIR II.—♂ common (1) × ♀ common (A 1), 1898.			
B 1	p.m. Jan. 4.....	No development.	
B 2	p.m. Jan. 6.....	12 m. Jan. 23.....	16 to 17 das.
D 1	5 ^h 15 ^m p.m. Feb. 25.....	4 to 6 a.m. Mar. 16.....	18 das. less 12 hrs., nearly.
D 2	p.m. Feb. 27.....	6 to 7 a.m. Mar 16.....	16 das. 12 hrs., nearly.
PAIR III.—♂ Satinette and ♀ Satinette, 1898.			
C 1	4 ^h 05 ^m p.m. Mar. 22.....	7 to 8 a.m. Apr. 10.....	18 das. 15 to 16 hrs.
C 2	2 ^h 30 ^m to 3 ^h 30 ^m p.m. Mar. 24..	1 to 2 p.m. Apr. 10.....	16 das. 21½ to 23½ hrs. (A 15)

¹ In this and succeeding tables the time determinations of much reliability and accuracy are set in special type.—EDITOR.

This subject has interested me for some time past, but for the present purpose I have just had time to collect the data, and I give them without having had much time to reflect upon them. My study of the subject is not yet concluded.² In this investigation it is necessary to learn the normal incubation time of the species used in the crosses and then the incubation period for the germs which represent the cross. In the common dove (*Columba domestica*) the result of all the tests I have made till now justify me in placing the incubation period for the first egg of the clutch at 18 days and for the second egg at 17 days (table 178). In determining the

¹ Stenographic report (slightly corrected by the author and adapted by the editor) of a lecture to the Zoological Club, The University of Chicago, March 9, 1898.

² The results of later studies have been incorporated in this chapter.—EDITOR.

duration of incubation one meets with the difficulty that the incubation for the second egg is not the same as that for the first. All doves have the habit of "half-sitting" on the first egg during the first day; sometimes they will even leave it uncovered during the first night. As a rule the parents stand over the egg with feathers just touching it, keeping it a little warm, but not as thoroughly warm as if the bird sat closely. After the second egg is laid doves begin to sit steadily and closely, leaving it rarely and for only very short periods.

The incubation time for the first egg in the ring-dove (*Streptopelia risoria*) is 15 days, plus or minus a few hours; for the second egg the period is 14 days minus, or, in rare cases, plus a few hours. The incubation periods of the common dove and the ring-dove differ therefore by about 3 days. What happens if we take a male with a longer incubation period and a female with a shorter period? Do the eggs hatch earlier or later? My first impressions in regard to this matter were that the egg always developed according to its normal rate, no matter what male united with the female; the egg seemed to follow only its own regular period. But in order to decide the matter the value of a few hours of difference must be made certain and the various necessary conditions and crosses considered. I have looked at the various difficulties, and it has seemed to me necessary not only to follow up the common doves and ring-doves, making sure of the normal period of incubation of the two species, but also to follow up very closely the crossed birds, noting the nature and constancy of incubation. It is also further necessary to make the crosses in both directions, and if possible at exactly the same season. I have had thus far but two cases³ from the crossing with the male ring-dove, so that there my observations can not be considered conclusive; they do seem, however, to be of interest.

TABLE 179.—Incubation time of eggs of ring-dove fertilized by common pigeons.

Pairs.	Eggs.	Laid.	Hatched.	Incubation.
♂ White fantail (FB) ...	A 1	4 ^h 58 ^m p.m. Apr. 17, 1897.	No development.	
♀ Ring-dove	A 2	7 ^h 43 ^m a.m. Apr. 19, 1897.	7 ^h 30 ^m May 4.....	15 das. less 13 m.
♂ Homer (Hom 1) ... ♀ Ring-dove (M 2)	A 1	4 ^h 45 ^m p.m. Mar. 11.....	12 noon Mar. 27.....	15 das. 19 hrs. 15 m.
	A 2	9 ^h 16 ^m a.m. Mar. 13.....	5 to 6 a.m. Mar. 28.....	14 das. 20 to 21 hrs.
	C 1	5 ^h 29 ^m p.m. Apr. 30.....	6 ^h 05 ^m a.m. May 16.....	15 das. 12 hrs. 36 m.
	C 2	9 ^h 10 ^m a.m. May 2.....	5 to 6 a.m. May 17.....	14 das. 20 to 21 hrs.
♂ Homer (1) ... ♀ Ring-dove (F)	A 1	4 ^h 39 ^m p.m. June 5.....	5 ^h 30 ^m a.m. June 21.....	15 das. 13 hrs.
	A 2	7 ^h 55 ^m a.m. June 7.....	6 ^h 00 ^m p.m. June 21 ¹	14 das. 10 hrs.
	C 1	6 ^h 50 ^m p.m. Aug. 13.....	5 to 6 a.m. Aug. 29.....	15 das. 11 hrs.
	C 2	8 ^h 45 ^m a.m. Aug. 15.....	Failed.	
Common dove (Wh) ♀ Ring dove (D 2)	D	4 ^h 05 ^m p.m. Sept. 5.....	12 ^h 30 ^m p.m. Sept. 20.....	14 das. 20 hrs. 25 m.
	C 1	4 to 6 p.m. Jan. 12, 1898	Failed.	
	C 2	7 to 9 a.m. Jan 14.....	6 ^h 00 ^m to 6 ^h 30 ^m a.m. Jan. 29..	14 das. 20 to 22 hrs. (A 15)

¹ This egg was opened; it would have hatched next morning.

In the cross of the ring-dove female and the common dove male, the incubation period of the first egg is 15 days plus a number of hours; for the second egg it is 14 days plus a number of hours (see tables 179, 180, 181, and 182). This rather closely approaches the normal, the normal being 15 days plus or minus for the first and 14 days minus or plus for the second (see tables 183 and 185). The result all hangs on

One further case was later added to these; see table 184.—EDITOR.

a certain number of hours. The male has not very much prolonged the period of incubation, but before I can say he has not affected it I have to consider the facts to be learned from the reciprocal cross, from crosses made simultaneously, if possible, and from crosses of still other species.

TABLE 180.—Incubation period of ♂ archangel (Ar 1) × ♀ ring-doves (D 1 and D 2).

Eggs.	Laid. ¹	Hatched.	Incubation.	Remarks. ¹
A 1	4 ^h 00 ^m to 4 ^h 30 ^m p.m. Feb. 18, 1897...	11 to 12 a.m. Mar. 6.	15 das. 19 to 20 hrs.	Interval, 1 da. 17 hrs. 29 m nearly.
A 2	9 ^h 29 ^m a.m. Feb. 20, 1897.....	Thin shell.....	Not tested.	
B 1	4 ^h 55 ^m p.m. Mar. 14.....	No development.....		Interval, 1 da. 17 hrs. 35 m.
B 2	10 ^h 30 ^m a.m. Mar. 17.....	Developed, died.....		
C 1	5 ^h 18 ^m p.m. Apr. 6.....	No development.....		{Interval not certain; C 1 laid 5 days after removal of eggs.
C 2	a.m. Apr. 8.....	No development.....		
D 1	6 ^h 12 ^m p.m. Apr. 29.....	No development.....		D 1 laid 5 days after removal of eggs.
D 2	a.m. May 1.....			
E 1	5 ^h 26 ^m p.m. May 11.....	No development.....		E 1 laid 6 days after removal of eggs. Interval, 1 da. 15 hrs. 19 m.
E 2	8 ^h 45 ^m a.m. May 13.....			
F 1	5 ^h 27 ^m p.m. June 6.....	No development.....		Interval, 1 da. 15 hrs. 30 m
F 2	8 ^h 57 ^m a.m. June 8.....			
G 1	5 ^h 37 ^m p.m. June 26.....	No development.....		Interval, 1 da. 15 hrs. 34 m.
G 2	9 ^h 11 ^m a.m. June 28.....			
H 1	5 to 6 p.m. July 12.....	No development.		
H 2	a.m. July 14.....			
I 1	5 ^h 48 ^m p.m. Aug. 2.....	9 to 1 p.m. Aug. 18...	15 das. 16 to 20 hrs.	Interval, 1 da. 14 hrs. 49 m.
I 2	8 ^h 37 ^m a.m. Aug. 4.....	Pricked shell, failed...		
J 1	5 ^h 34 ^m p.m. Aug. 29.....	No development.....		Interval, 1 da. 15 hrs. 16 m
J 2	8 ^h 50 ^m a.m. Aug. 31.....			
A 1	3 ^h 47 ^m p.m. Jan. 28, 1898.....	Developed, died.....		Eggs by second ♀ (D 2).
A 2	a.m. Jan. 30, 1898.....	No development.		
B 1	p.m. Feb. 19.....	Pricked shell, failed...		Eggs by second ♀ (D 2). (A 15)
B 2	a.m. Feb. 21.....	No development.		

Summary: Time, Feb. 18, 1897, to Mar. 1898. Of 24 eggs, 2 hatched, 6 fertilized; none reared.

¹ Some data referred to in various chapters of Vol. III are presented in connection with this and succeeding tables.—EDITOR.

TABLE 181.—Incubation period of ♂ black Japanese tumbler (T 3) × ♀ ring-dove (L. 1).

Eggs.	Laid.	Hatched.	Incubation.
A 1	5 p.m. July 23, 1897.....	No development.	14 das. 4 to 7 hrs.
A 2	7 to 9 a.m. July 25, 1897.....	1 to 2 p.m. Aug. 8.....	
B 1	4 to 6 p.m. Aug. 25.....	5 to 6 a.m. Sept. 10.....	15 das. 11 to 14 hrs.
B 2	8 a.m. Aug. 27.....	Developed, did not hatch.	
C 1	p.m. Sept. 26.....	Lost.	
C 2	a.m. Sept. 28.		
D 1	Time not noted; about Oct. 9....	No development.	
D 2			
E 1	4 ^h 08 ^m p.m. Oct. 21.....	12 noon, Sat., Nov. 6....	15 das. 20 hrs.
E 2	a.m. Oct. 23.....	No development.	
F 1	3 ^h 36 ^m p.m. Dec. 13.....	7 a.m. Dec. 30.....	16 das. 15 hrs. ¹
F 2	8 to 9 a.m. Dec. 15.....	6 a.m. Dec. 30.....	14 das. 21 to 22 hrs.
G 1	4 to 6 p.m. Jan. 20.....	Pricked shell, failed.	14 das. 20 to 22 hrs.
G 2	7 to 9 a.m. Jan. 22.....	a.m. Feb. 6.....	
H 1	5 p.m. Feb. 19.....	12 to 1 Mar. 7.....	15 das. 19 to 20 hrs.
H 2	a.m. Feb. 21.....	Pricked shell, failed.	

Summary: Time, July 1897, to March 1898; 16 eggs; reared 5, hatched 7, 10 fertilized.

(A 15)

¹ Hatched only with help and soon died; the hatching was abnormally delayed, perhaps from imperfect development.

The results of two such reciprocal crosses incubated simultaneously, and with the eggs of the crossed birds interchanged with uncrossed birds for incubation purposes, may be found in table 185. It is there indicated that the sperm of the male tumbler added 7 to 24 hours to the incubation period.

Eggs from a further cross between a male ring-dove and a female homer were incubated simultaneously with eggs from three pairs of common pigeons. The result, as seen in table 186, indicated a shortening of the period by about 8 to 26 hours as a result of fertilization by the ring-dove male.

I have studied the incubation period of the eggs of the wild passenger-pigeon (*Ectopistes migratorius*) and have also obtained data on the length of this period

TABLE 182.—Incubation time of ♂ common dove (Z) × ♀ ring-dove (D 2).

Eggs.	Laid.	Hatched.	Incubation.
A 1	4 to 6 p.m. May 3, 1896.....	No development.	15 das. 18 to 19 hrs.
A 2	8 to 9 a.m. May 5, 1896.....	No development.	
B 1	4 to 6 p.m. May 23.....	11 to 12 a.m. June 8.	
B 2	8 ^h 50 ^m a.m. May 25.....	Developed, did not hatch.	
C 1	5 to 6 p.m. June 19.....	No development.	Removed July 28.
C 2	9 ^h 53 ^m a.m. June 21.....	No development.	
D 1	p.m. July 1.....	No development.	
D 2	a. m. July 3.....	No development.	
E 1	5 ^h 30 ^m p.m. July 20.....	No development.....	Removed July 28.
E 2	8 ^h 30 ^m to 8 ^h 45 ^m a.m. July 22...	No development.	
F 1	5 ^h 30 ^m to 6 p.m. Aug. 2.....	Developed to about a week.	
F 2	7 to 9 a.m. Aug. 4.....	No development.	
G 1	4 to 5 p.m. Aug. 24.....	No development.	15 das. 3 hrs. (long for 2d egg).
G 2	8 to 9 a.m. Aug. 26.....	No development.	
H	3 ^h 50 ^m p.m. Sept. 11.....	No development.	
I 1	4 to 4 ^h 45 ^m p.m. Oct. 11.....	No development.	
I 2	8 ^h 47 ^m a.m. Oct. 13.....	No development.	15 das. 12 to 13 hrs.
J 1	4 to 5 p.m. Oct. 31.....	No development.	
J 2	8 ^h 55 ^m a.m. Nov. 2.....	12 noon Nov. 17.....	
K 1	4 to 5 p.m. Nov. 30.....	Developed to one week.	
K 2	9 ^h 16 ^m a.m. Dec. 2.....	No development.	14 das. 18 to 20 hrs.
L 1	4 to 6 p.m. Dec. 20.....	Before 6 a.m. Jan. 5, 1897	
L 2	9 ^h 20 ^m a.m. Dec. 22.....	No development.	
M 1	5 ^h 05 ^m p.m. Jan. 23.....	No development.	
M 2	10 ^h 05 ^m Jan. 25, 1897.....	Before 6 a.m. Feb. 9.....	15 das. 12 to 13 hrs.
N 1	5 ^h 04 ^m p.m. Feb. 26.....	Developed for week only.	
N 2	9 ^h 28 ^m a.m.....	Developed but killed.	
O 1	4 ^h 42 ^m p.m. Mar. 19.....	5 to 6 a.m. Apr. 4.....	
O 2	9 ^h 16 ^m a.m. Mar. 21.....	No development.	15 das. 11 to 13 hrs.
P 1	4 to 6 p.m. Apr. 17.....	Developed but stopped.	
P 2	7 ^h 50 ^m a.m. Apr. 19.....	Developed but stopped.	
Q 1	5 ^h 53 ^m p.m. May 16.....	No development.	
Q 2	a.m. May 18.		14 das. 20 to 23 hrs.
R 1	5 ^h 08 ^m p.m. May 30.....	No development.	
R 2	7 ^h 50 ^m a.m. June 1.....	Developed, failed.	
S 1	6 ^h 21 ^m p.m. June 20.....	Developed, failed.	
S 2	8 ^h 53 ^m a.m. June 22.....	No development.	15 das. 11 to 13 hrs.
T 1	5 to 6 p.m. July 12.....	5 to 6 a.m. July 28.....	
T 2	7 to 9 a.m. July 14.....	5 to 6 a.m. July 29.....	
U 1	4 to 7 p.m. Aug. 22.....	No development.	
U 2	Premature.....	Not tested.	(A 15)

Time: May 3, 1896, to Aug. 22, 1897; 41 eggs; raised 4 males; 7 hatched; 16 fertilized.

when the passenger male was crossed with ring-dove females. This pigeon has the shortest incubation period known among doves and pigeons. The period is here a little less than 13 days; it averages about $12\frac{1}{2}$ days (see table 187). This is a shorter period than that of the ring-dove, in which, as we have seen, the period is 14 to 15 days. The passenger-pigeon's incubation time is nearly as much short of that of the ring-dove as the period of the latter is short of the common pigeon. What is the effect on the incubation time of uniting the male passenger-pigeon and the female ring-dove? The answer from our data is as follows: For the first egg the period is 14 days plus 20 hours; for the second 13 days plus 6 to 20 hours (see tables 188 and 189). These figures come close to the normal range for the ring-dove; still I can not help feeling that there is some influence, however small, exercised by the male on the rate of development. Comparing the results obtained with the passenger-pigeon and the common pigeon, when each of these mated to the ring-dove, we find these give us the two extremes. In a condensed form these two crosses may be stated to stand as follows: Common pigeon male \times ring-dove female: first egg, 15 days plus; second egg, 14 days plus. Passenger-pigeon male \times ring-dove female: first egg, 14 days plus 20 hours; second egg, 13 days plus 6 to 20 hours. Females of the same species (*St. risoria*) are used in both cases; different males are given. One of these males represents an incubation period of about $12\frac{1}{2}$ days, the other a period of 17 to 18 days. The difference in the result is small, but it is enough to indicate that there is a small though measurable influence of the male on the rate of development. (A more complete summary of these crosses of ring with domestic and passenger-pigeons is given in table 190.—EDITOR.)

The red ring-dove of Japan (*Streptopelia humilis*) has also a short incubation period. This dove, too, has been crossed with the ring-dove, with the result made clear by table 191. The males of this species, too, shortened the period of development in the egg of the ring by from 12 to 24 hours. The three incubations bearing on this point were made simultaneously.⁴

The effect⁵ of the sperm of one species on the rate of development of the eggs of another species was observed in many isolated instances with several different crosses. Some of these have been referred to in connection with the tabulated breeding records. Two cases may be added here.

In the cross of the female wood-pigeon (*Columba palumbus*) with a male common pigeon "about one day" was added to the incubation period; this was found in two cases. (A 14) Another series of matings supplied data for a reciprocal cross. In a female *Columba guinea*, whose normal period is 16 days plus 12 hours for the first egg and 15 days plus 16 to 18 hours (XS 3) for the second, the period became 17 days plus 12 hours for the first egg when mated with a *C. domestica*. In the reverse cross a male *C. guinea* shortened by $1\frac{1}{2}$ days the time of hatching of an egg of a homer, the period becoming 16 days plus 20 to 22 hours. "This time is $1\frac{1}{2}$ days shorter than in homers and common pigeons and again is a proof that the male influences the rate or speed of development."⁶ (G 3)

⁴ Nearly all of the data for the preceding parts of this manuscript were obtained from original data catalogued as A 111, A 15, A 16, and R 18.—EDITOR.

⁵ The concluding paragraphs were written by the editor.

⁶ There is reason to believe that there are many phenomena of inheritance in hybrids—particularly the differences of reciprocal hybrids—which will, at some time, be found to be based essentially upon the "different rates of development" of the forms crossed. If so, such phenomena should perhaps be more easily discovered and analyzed in crosses of annual with biennial plants; but they are probably also discoverable in animal crosses.—EDITOR.

INHERITANCE, FERTILITY, AND SEX IN PIGEONS.

TABLE 183.—*Normal incubation time of ring-doves ($\sigma A \times \phi A$).*

Eggs.	Laid.	Hatched.	Incubation.
J 1	4 to 6 p.m. Mar. 12, 1895.....	12 to 6 p.m. Mar. 28.....	15 das. 18 to 20 hrs.
J 2	8 to 9 a.m. Mar. 14.....	12 to 6 p.m. Mar. 28.....	14 das. less 4 hrs. at least.
K 1	4 to 5 p.m. Apr. 15.....	5 to 7 a.m. Apr. 30.....	14 das. 15 to 17 hrs.
K 2	8 ^h 38 ^m a.m. Apr. 17.....	Opened.	
L 1	5 ^h 15 ^m to 5 ^h 45 ^m p.m. May 13....	5 to 7 a.m. May 28.....	14 das. 12 hrs. nearly.
L 2	8 to 8 ^h 30 ^m a.m. May 15.....	5 to 7 a.m. May 29.....	14 das. less 4 hrs., at least.
M 1	4 ^h 46 ^m p.m. June 18.....	a.m. July 4.....	15 das. 12 to 14 hrs.
M 2	8 to 8 ^h 45 ^m a.m. June 20.....	a.m. July 5.....	14 das. 20 to 22 hrs.
N 1	4 ^h 35 ^m p.m. July 25.....	5 to 6 a.m. Aug. 9.....	14 das. 12 to 13 hrs.
N 2	7 ^h 36 ^m a.m. July 27.....	12 ^h 30 ^m p.m. Aug. 10.....	14 das. 5 hrs.
O	4 ^h 40 ^m p.m. Aug. 31.....	Sept. 16.....	(?)
P 1	4 to 6 p.m. Oct. 15.....	10 a.m. Oct. 31.....	15 das. 20 hrs. nearly.
P 2	8 to 9 a.m. Oct. 17.....	2 p.m. Oct. 31.....	14 das. 5 to 6 hrs.
Q 1	3 ^h 30 ^m to 5 ^h 30 ^m p.m. Dec. 21....	12 to 3 ^h 30 ^m p.m. Jan. 6, 1896	15 das. 8 to 12 hrs.
Q 2	9 ^h 20 ^m a.m. Dec. 23.....	2 p.m. Jan. 6, 1896.....	14 das. 3 hrs. 40 m. (A 15)

TABLE 184.—*Incubation time of eggs of σ alba \times risoria (ring) \times ϕ homer.*

Eggs.	Laid.	Hatched.	Incubation.	Remarks.
A 1	p.m. June 16, 1897.....	No development.....		Removed after 4 or 5 days
A 2	p.m. June 18.....	No development.....		
B 1	p.m. June 28.....	Development began; egg lost		
B 2	p.m. June 30.....	No development.		
C 1	6 p.m. July 13.....	No development.		
C 2	p.m. July 15.....	No development.		
D 1	5 to 6 p.m. July 29.....	No development.		
D 2	Before 4 p.m. July 31.....	No development.		
E 1	p.m. Aug. 12.....	No development.		
E 2	p.m. Aug. 14.....	No development.		
F 1	5 ^h 37 ^m p.m. Aug. 29.....	Developed only for a week or 10 days, then failed.		
F 2	p.m. Aug. 31.....	No development.		
G 1	5 ^h 20 ^m p.m. Oct. 7.....	No development.		
G 2	p.m. Oct. 9.....	No development.		
H 1	5 ^h 18 ^m p.m. Oct. 23.....	No development.		
H 2	p.m. Oct. 25.....	No development.		
I 1	p.m. Dec. 16.....	No development.		
I 2	p.m. Dec. 18.....	No development.		
J 1	p.m. Jan. 9.....	9 a.m. Jan. 27.....	17 das. 16 hrs. nearly...	Helped out of shell.
J 2	p.m. Jan. 11.....	No development.		
K 1	6 ^h 15 ^m p.m. Feb. 10.....	No development.		
K 2	2 ^h 55 ^m p.m. Feb. 12.....	3 ^h 30 ^m to 4 a.m. Feb. 28....	15 das. 12½ to 13 hrs.	(A 15)

TABLE 185.—*Concomitant incubation: Two crosses and two normals, with eggs interchanged.*

Birds.	Eggs.	Laid.	Hatched.	Incubation.
σ Archangel (Ar 1).....	{ B 1	4 to 6 p.m. Feb. 19	Pricked shell.....	Not certain.
ϕ Ring-dove (D 2).....		7 to 9 a.m. Feb. 21	No development.	
σ Ring-dove (G).....	{ Z 1	4 to 6 p.m. Feb. 19.	12 to 2 Mar. 6....	14 das. 19 to 21 hrs.
ϕ Ring-dove (G).....		7 to 9 a.m. Feb. 21.	5 to 6 a.m. Mar. 7.	13 das. 21 to 22 hrs.
σ Black Jap. tumbler (T 3)....	{ H 1	5 p.m. Feb. 19....	12 to 1 Mar. 7....	15 das. 19 to 20 hrs.
ϕ Ring-dove (L 1).....		7 to 9 a.m. Feb. 21	Failed.	
σ Ring-dove (C).....	{ Z 1	4 to 6 p.m. Feb. 19.	5 to 6 a.m. Mar. 7	15 das. 12 hrs., nearly.
ϕ Ring-dove (C).....		7 to 9 a.m. Feb. 21.	p.m. Mar. 7.....	14 das. (A 15)

TABLE 186.—*Contemporaneous incubation period in 4 cases.*

Pairs.	Parents.	Eggs.	Laid.	Hatched.	Incubation.
I	Com 4 (chequered).....	{ B 1	p.m. July 8, 1898.....	Before 6 a.m. July 27...	18 das. 12 hrs., ca.
	Com 5 (slate—2 bars).....	{ B 2	p.m. July 10.....	At 6 a.m. July 27.....	16 das. 12 hrs., ca.
II	Com 1 (3 brown bars).....	{ H 1	p.m. July 9.....	1 to 2 p.m. July 27.....	17 das. 19 to 20 hrs., ca.
	Com 1-A 1 (slate—3 bars)...	{ H 2	p.m. July 11.....	Before 6 a.m. July 28...	16 das. 12 to 20 hrs.
III	Hom 2 (slate—2 bars).....	{ F 1	p.m. July 9.....	11 ^h 40 ^m a.m. July 27...	17 das. 18 to 20 hrs.
	Com 1-D 2 (slate—3 bars)...	{ F 2	Before 2 p.m. July 11...	By 6 a.m. July 28.....	16 das. 12 to 20 hrs.
IV	Ring hybr. (alba-ris.).....	{ P 1	7 ^h 05 ^m p.m. ¹ July 9.....	6 a.m. July 27.....	17 das. 10 to 11 hrs.
	Homer.....	{ P 2	p.m. July 11.....	No development.	

Summary: I to III are 3 pairs of common pigeons; IV is a cross of a male ring (*alba* × *risoria*) × female homer. Time of IV nearly agrees with II and III; is a little less for their first eggs; it is considerably less than first of I. I, II, and III agree on second eggs; the first egg has longer time, probably due to lighter sitting for first two days. (A 15)

¹ The figure given here, 7^h 05^m, is almost certainly wrong; the correct time was almost certainly 2^h 05^m. If this is true the incubation time for this egg is 5 hours longer than indicated by the calculation given above; i.e., it was 17 days plus 15 to 16 hours.—EDITOR.

 TABLE 187.—*Normal incubation time of Ectopistes migratorius (4 pairs).*

Pairs.	Laid. ¹	Hatched.	Incubation.
I F	5 ^h 25 ^m p.m. Apr. 28, 1897.....	2 to 3 p.m. May 11.....	13 das., less a few hours.
II C	p.m. Aug. 22, 1897.....	Before 2 ^h 30 ^m p.m. Aug. 4...	12 das. 12 to 18 hrs.
III D	6 p.m. Aug. 15.....	Aug. 28.....	12 das. 12 to 18 hrs.
I H	5 to 6 p.m. May 30.....	a.m. June 12.....	12 das. 12 to 13 hrs.
IIb A	7 ^h 05 ^m p.m. May 9.....	7 ^h 20 ^m a.m. May 22.....	12 das. 12 hrs. 15 m.
III B	p.m. Apr. 30.....	Before 4 p.m. May 13.....	13 das. less a few hours. (A 15)

¹ Clutches of only 1 egg each are laid by this species.—EDITOR.

 TABLE 188.—*Incubation period of ♂ passenger × ♀ ring hybrid (alba-risoria × risoria-alba, C 1).*

Eggs.	Laid.	Hatched.	Incubation.
A 1	3 ^h 20 ^m p.m. Apr. 4, 1898.....	No development.	
A 2	7 ^h 40 ^m a.m. Apr. 6, 1898.....	4 to 5 a.m. Apr. 20.....	13 das. 20½ to 21½ hrs.
C 1	4 ^h 30 ^m to 5 ^h 30 ^m p.m. Apr. 15...	5 a.m. May 1.....	15 das. 12 hrs., nearly.
C 2	a.m. Apr. 17.....	No development.	(A 15)

 TABLE 189.—*Incubation period for ♂ Ectopistes (IA) × ♀ ring-dove (L 2).*

Eggs.	Laid.	Hatched.	Incubation.
A	3 to 5 ^h 30 ^m p.m. Jan. 26.....	Failed.	
B 1	4 to 6 p.m. Mar. 1.....	8 a.m. Mar. 16.....	14 das. 15 hrs., ca.
B 2	9 ^h 48 ^m a.m. Mar. 3.....	No development.	
C 1	5 ^h 10 ^m p.m. Mar. 13.....	No development.	
C 2	9 ^h 02 ^m a.m. Mar. 15.....	No development.	
D 1	4 ^h 50 ^m p.m. Mar. 27.....	Failed to hatch.	
D 2	9 ^h 07 ^m a.m. Mar. 29.....	6 ^h 10 ^m a.m. Apr. 12.....	14 das. 21 to 22 hrs.
E 1	5 ^h 02 ^m p.m. Apr. 9.....	6 ^h 50 ^m a.m. Apr. 24.....	14 das. 14 hrs.
E 2	8 to 9 a.m. Apr. 11.....	No development.	
F 1	4 ^h 42 ^m p.m. Apr. 18.....	Failed.	
F 2	8 ^h 25 ^m a.m. Apr. 20.....	4 to 5 a.m. May 4.....	14 das. less 4 to 5 hours.
G 1	5 ^h 10 ^m p.m. Apr. 30.....	1 ^h 50 ^m p.m. May 14.....	14 das. less 3 hours.
G 2	9 ^h 14 ^m a.m. May 2.....	3 ^h 41 ^m p.m. May 15.....	13 das. 6 hrs. 27 m.

TABLE 189—(continued).

Eggs.	Laid.	Hatched.	Incubation.
H 1	5 ^h 37 ^m p.m. May 10.....	No development.	
H 2	9 ^h 36 ^m a.m. May 12.....	4 to 5 a.m. May 26.....	14 das. less 5 to 6 hrs.
I 1	4 ^h 05 ^m p.m. June 5.....	} Developed but failed to hatch.	
I 2	6 ^h 21 ^m a.m. June 7.....		
J 1	p.m. June 28.....	} Developed but failed to hatch.	
J 2	a.m. June 30.....		
K	3 ^h 42 ^m p.m. July 10.....	No development.	
L	p.m. Aug. 4.....	6 a.m. Aug. 19.....	14 das. 12 hrs., nearly.
M 1	5 ^h 48 ^m p.m. Aug. 13.....	Partly hatched but died in shell.	Not quite 15 days.
M 2	8 ^h 37 ^m a.m. Aug. 15.....	2 ^h 30 ^m p.m. Aug. 28; opened.	
N	p.m. Sept. 8.....	No development.	
O 1	p.m. Oct. 6.....	No development.	
O 2	a.m. Oct. 8.....		
P 1	5 to 6 p.m. Mar. 24, 1898.....	1 to 2 p.m. Apr. 9.....	15 das. 19 to 21 hrs.
P 2	9 ^h 30 ^m to 10 a.m. Mar. 26, 1898.	6 a.m. Apr. 11.....	15 das. 20 to 20½ hrs. (A 15)

TABLE 190.—Summary on period of incubation.

- ♂ Common dove × ♀ common dove, period for { first egg, 18 days, nearly.
second egg, 17 days, nearly.
- ♂ *Ectopistes* × ♀ *Ectopistes* (single egg in clutch), 12½ days, nearly.
- ♂ Ring-dove × ♀ ring-dove, period for..... { first egg, 15 days + or —.
second egg, 14 days — or +.

Crosses of common doves and *Ectopistes* with ring-doves:

- I. ♂ common doves × ♀ ring, period for.. { first egg, 15 days +.
second egg, 14 days +.
- II. ♂ *Ectopistes* × ♀ ring, period for..... { first egg, 14 days 12 to 20 hours.
second egg, 13 days 6 to 20 hours.

(A 15)

TABLE 191.—Crosses of *St. humilis* with *St. risoria*; eggs incubated simultaneously.

Pairs.	Eggs.	Laid.	Hatched.	Incubation.
I ♂ <i>St. humilis</i> ♀ <i>St. humilis</i>	F 1	p.m. Aug. 31, 1900...	5 to 6 a.m. Sept. 14...	13 das. 12 to 14 hrs.
	F 2	5 to 6 a.m. Sept. 2....	5 to 6 a.m. Sept. 15...	12 das. 20½ hrs.
II ♂ <i>humilis</i> ♀ <i>risoria</i>	F 1	p.m. Aug. 30.....	(hr. ?) Sept. 13.....	13 das. 12 to 23 hrs.
	F 2	a.m. Sept. 1.....	3 ^h 30 ^m p.m. Sept. 14...	13 das. 6 to 8 hrs.
III ♂ <i>alba-ris</i> × <i>ris-alba</i> ♀ <i>risoria</i>	L 1	p.m. Aug. 29.....	(hr. ?) Sept. 13.....	14 days+. ¹
	L 2	a.m. Aug. 31.....	a.m. Sept. 15.....	14 days+.

(R 18)

¹ "I don't think this is quite a typical instance." (The period is usually a little longer for the first egg.—EDITOR.)

"Comparing the second eggs of pairs I and II, the cross (II) gave a period of 13 days plus 6 to 8 hours; the uncrossed pair (I) showed a period of 13 days less 2½ to 3½ hours. This is a difference of a little less than 12 hours."

CHAPTER XVII.

ON THE DIVISIBILITY OF CHARACTERS.

Specific characters, by hybridizing, can be divided, subdivided, etc., until it is seen that two different characters are brought to an equality. Where two species have different characters, one can get every degree of splitting or division.

If the characters of the crossed birds are the same, then the resulting hybrid has the full unreduced character.

AN EXHIBITION OF HYBRIDS¹ SHOWING THE DIVISIBILITY OF CHARACTERS.

Professor Brooks has defined heredity as "the resemblance of child to parent, of offspring to ancestor; while the difference between child and parent is called variation."²

Most of us feel that this definition covers the ground. In the investigation of heredity, or in a discussion of it, it is, however, extremely difficult to limit ourselves to single things; and the only way to do it—if there is any way to do it—is to get some particular objects before our eyes and make the effort to see for ourselves what is to be seen. At this time I shall content myself with exhibiting a few pictures and a few living birds to illustrate what happens in the crossing of different species of pigeons.

In this field, as in most other fields, a single fact, or what we can learn from a single fact, is simply illustrative of what can be found in the rest of the field. The first hybrids that I shall discuss are those derived from the common ring-dove and the nearly extinct passenger-pigeon. Both sexes of the passenger-pigeon have been carefully represented in color drawings (the male in pl. 28 and the female in pl. 29). The main distinction between the sexes is that the female has a duller color, has more brown, is rather larger, and has more numerous spots on the wing. The male has apparently lost a certain number of these spots and has reduced the size of the rest, some of them being so minute that they can scarcely be seen. Some of them are concealed under the wing-coverts, where, of course, they can have very little ornamental importance.³ The blond ring-dove may also be seen in color (pl. 8); the neck-mark or ring of an adult female is better shown in pl. 31; the ring of a juvenal ring-dove is also shown in pl. 31.

The hybrids from the passenger \times ring-dove cross, of which some 8 or 10 have been obtained, were all males. The father of all these hybrids was a passenger-pigeon and the mother a ring-dove. The hybrids (one shown in pl. 30) will perhaps best be compared with the male of the paternal species. An examination of the neck-mark attests that in this respect the hybrid stands as nearly intermediate between its two parents as is possible. The color of this region is lighter in the hybrid than in the passenger-pigeon, and that is of course in the direction of the ring-dove. The passenger-pigeon shows a plain iridescence on the side of the neck. In the hybrid there is a slight iridescence; and it has in addition the differentiation of the feathers of the ring that carries it beyond the passenger-

¹ The manuscript (SS 11) used in this chapter is a stenographic report, partly corrected by the author, of a lecture at Woods Hole, July 19, 1906. The editor has adjusted the manuscript to a place in this volume.

² W. K. Brooks, *Proc. Amer. Phil. Soc.*, No. 182, April 1906, p. 70.

³ See text-figs. 5 to 7, Vol. I.

pigeon in the direction of the ring-dove. The differentiation does not meet on the back of the neck as it does in the case of the ring-dove, but it extends farther towards the middle of the back of the neck than does the iridescent area of the passenger-pigeon.

The tail of the hybrid is considerably longer than it is in the ring-dove, but falls plainly short of the length attained in the passenger-pigeon. The general appearance of the bird in size, color, and marking is intermediate. There are none of the black spots of the passenger-pigeon shown distinctly in the hybrid, except in the feathers on the posterior border of the wing. In the cage of living birds⁴ one could probably identify the hybrid whose picture has just been shown, although the two birds together there are nearly of the same size. One can see the marking on the neck of the one bird, and note that although it is slightly separated posteriorly it comes near to a union on the back of the neck. A close examination of the hybrid shows that there are some obscure marks on the scapulars, directly in the middle of the back, and that there are also the faintest traces of some marks in the tertials. Perhaps I have sufficiently described this hybrid; I think the bird exhibited here is a fair intermediate between the two parent species.

When I first began my experiments in hybridization I had much curiosity, hardly knowing what to think would be the result of crossing two birds so different as those just described. So far as the wild pigeons are concerned it was a wholly unknown field at the time. I continued my effort, however, and got all the hybrids I could—in the case of these two particular species I obtained 8 or 10 offspring. These were all males and all of the same color. It was difficult to find any difference between them. There was a slightly stronger trace of the spots in some cases than in others, and a slight difference in the length of the tail. They never, however, went much beyond the length seen in the individual exhibited here.

⁴ Some live birds were demonstrated in this lecture.—EDITOR.

EXPLANATION OF PLATE 32.

Fig. 1. Neck-mark of common pigeon × ring-dove hybrid. Toda del., Feb. 1903. × 1.1

Fig. 1. Rows drawn so as to show the extent of black and gray; sharply cut feathers, and feathers less cut, passing gradually into regular neck-feathers at each end of the rows and also above and below the rows.

Figs. 2-6. Natural size. Show five feathers (left side) taken (Feb. 27, 1903) as follows:

Fig. 2. Eighth feather of second row (counting from above downward). In this row we see 6 feathers shaded. These feathers are not black, but gray with pale-gray tips.

Fig. 3. Ninth feather of third row. This from just below the feather shown in fig. 2. Here also 6 feathers shaded, the 2 or 3 central ones becoming darker gray; darker on posterior web.

Fig. 4. Eighth feather of fourth row (fourth of 7 shaded feathers). From directly under that of fig. 3. Black or blackish gray; darkest on dorsal web.

Fig. 5. Eighth feather of fifth row. Not quite so dark as that of fig. 4.

Fig. 6. Seventh feather of sixth row. Slightly darker than fig. 2, but lighter than figs. 3, 4, or 5.

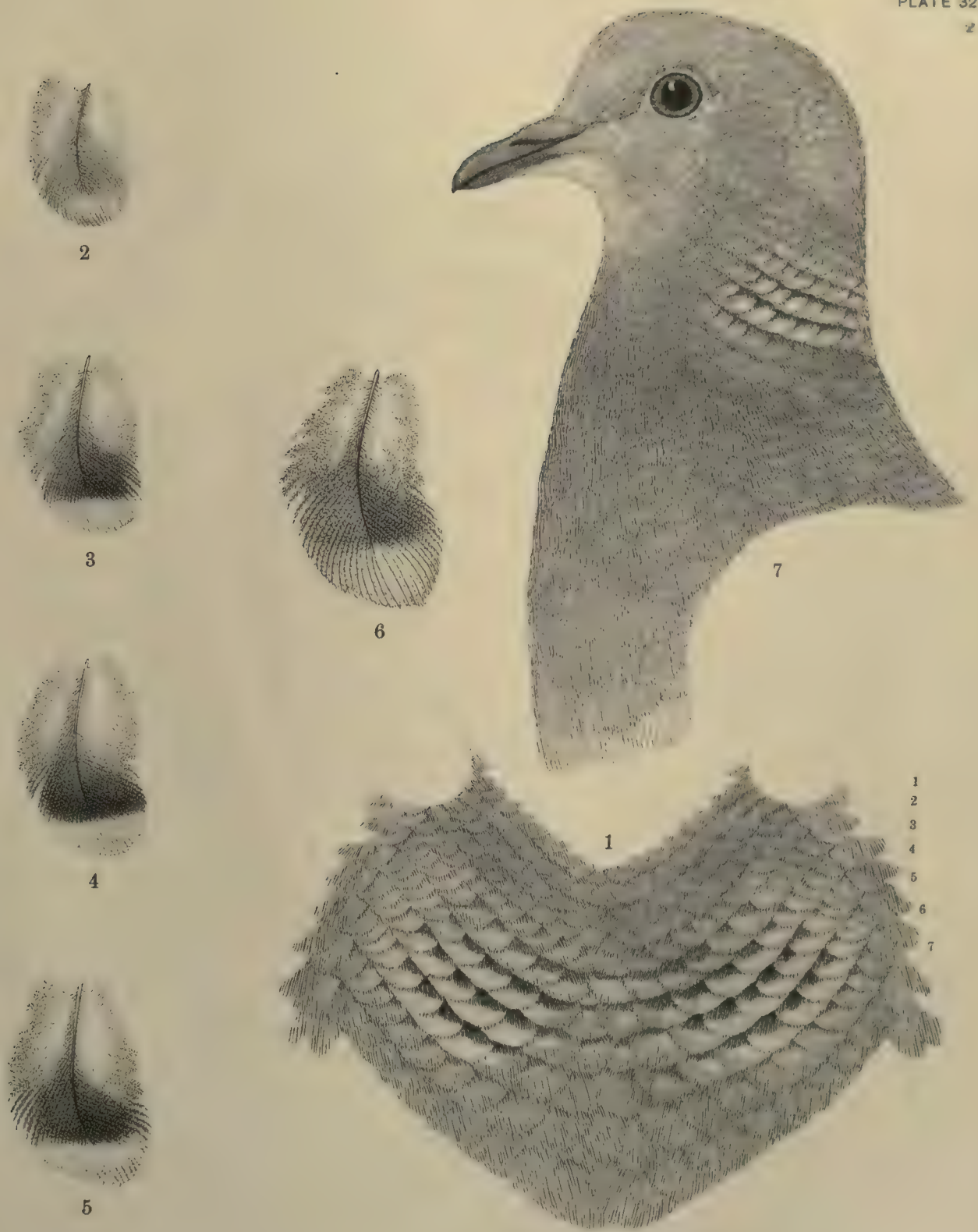
Fig. 7. Hybrid between a male black Japanese pigeon (T 3 = common pigeon, with a touch of fantail) and a female ring-dove (*St. risoria* × *St. alba*, XW2D1). × 0.6. Toda del., Feb. 1903.

This hybrid (T 1) was hatched Aug. 5, 1902. Head and neck to show the neck-mark (neck held at normal length). Three rows show blackish bases and metallic-gray tips. Above these three is one row in which blackish bases (dark gray) show only on lifting the feathers; the tips are gray becoming vinous iridescent at extreme tip. Then another row with little differentiation.

Below the three rows comes one which, in a little greater extension, shows black bases on 5 to 6 feathers, tips gray, passing into vinous iridescence at extreme tips; then another row showing no black, but tips lustrous vinous; only about 4 or 5 being cut shorter at tips. Thus there are about 7 rows.

All around the black and gray region, which corresponds to the ring-area in the ring-dove, there is vinous iridescence. No plain iridescence on front of neck, and but little on back of neck.

The same neck-mark flat, and isolated feathers, shown in figs. 1-6.



Neck-mark of common pigeon \times ring-dove hybrid; separate feathers from mark shown in figures 2 and 6. Toda del., Feb. 1903.



This bird was the only one of the fraternity having a white rump; it has 13 tail-feathers. The general color is gray; the wings are washed with brown, increasing on long coverts and tertials. The lower web of the feather has the most brown, and this is the only suggestion of dark chequers, but there is nothing like a distinct chequer. Occiput freckled with white. Iris bright red, with orange next to pupil. The neck-spot is a little stronger than the one shown in plate 32, fig. 7, but only 3 to 4 rows show black without lifting feathers. Feathers about the same as those in plate 32. During 1907-8 this hybrid acquired white tail-feathers.

TEXT-FIGURE 2.—Head and neck-mark of an adult male hybrid (K 1) between a white male fantail (*Columba laticauda*, F) and a female blond ring-dove (*Streptopelia risoria*, B). Hatched Dec. 1, 1897; age 6 years. $\times 1.2$. Toda del., Jan. 1903.



Shows neck-feathers of first or juvenal plumage; first molt was, however, already in progress. The rows of feathers are quite distinct and the distinctness is not overdrawn in the figure; a little less distinct than in the stock-dove (see text-figure 4).

TEXT-FIGURE 3.—Neck-mark of African owl pigeon, *C. turbata*; about 3 months old. Natural size. Hayashi del., 1900.

It will be seen, then, in this case, that we get nothing out of the pair of birds which is not in them to start with; when we have once learned that simple lesson we can begin to calculate what will happen in the case of any new cross. It is not now a matter of so great curiosity to me when I cross a pair of birds of different species; I can usually forecast in a general way what the result will be.

The next hybrid to be considered had an altogether different parentage, in so far as the male parent is concerned. The mother was the same species of ring-dove and the father a common pigeon—the homer. The homer differs from other common pigeons mainly in the size of the beak, which has a basal portion large as compared with the ordinary pigeon. The hybrids⁵ (pl. 32 and text-fig. 2) have also

⁵ The hybrids shown in the plates have other common pigeons, not homers, as sires.—EDITOR.

EXPLANATION OF PLATE 33.

Figs. 1-6. The Nicobar pigeon, *Caloenas nicobarica*. Habitat: From the Nicobars and Mergui Archipelago through Malay Archipelago as far as Solomon Islands (Salv., p. 617). Natural size. Hayashi del., Feb. 1903.

The feathers of the side of the neck (the region of the neck-mark in other pigeons) are much elongated. A similar elongation is seen in the hackled partridge (see Latham, Hist. of Birds, Vol. VIII, pl. cxxix, p. 307). These long feathers are 37 mm. long (some are longer in Nicobar). When erected they appear like those on the neck of the ruffled heath cock.

Neck-feathers (left side).

Fig. 1, from just under ear-coverts. Fig. 2, from middle of upper breast. Fig. 3, from just above middle of side. Fig. 4, from same height on mid-back of neck. Fig. 5, from middle of side of neck. Fig. 6, entire head and neck. $\frac{2}{3}$ natural size.

Figs. 7, 8, 9, 10, four feathers from neck of an adult male *Columba guinea*, and four feathers, figs. 11, 12, 13, and 14, from neck of a hybrid between a male *C. guinea* and a female *C. livia*. $\times 2$. Hayashi del., Apr. 1903.

The split or bifurcation is stronger in the male parent, while the iridescence is stronger in the hybrid, as we should expect, since *C. livia* is much more iridescent than *C. guinea*.

7 and 11. Taken (in each case) just below ear coverts on the left side; these are red and bifurcated in the parent, but gray and entire in the hybrid.

8 and 12. From near mid-height, side of neck. Longer and slenderer, and red in the male; wider and shorter, and gray in the hybrid. The split is longer in male, about equal in width.

9 and 13. From near lower boundary of bifurcated feathers on side of neck (in line with 1 and 2); split wider in the male.

10 and 14. From still lower. Little bifurcation in the male; none at all in the hybrid.

EXPLANATION OF PLATE 34.

Figs. 1, 2, 3. Adult male *St. risoria* ($\frac{1}{8}$)—*Spil. suratensis* ($\frac{1}{4}$) \times *St. alba* ($\frac{3}{8}$) hybrid (T 1). From egg of May 1, 1903. $\times 2$ Toda del., April 1904.

Fig. 1. The neck-mark, here shown flat, is smaller than in the male parent figured on this plate, figs. 4-6. The divided tip of the feathers is also here less marked than there. The neck-mark and divided tip of the *suratensis* grand-parent have thus been twice divided. The extent of the white tip on the feathers of the mark has also suffered two reductions from *suratensis* toward the ring-dove.

Fig. 2. Fifth feather, third row (right side).

Fig. 3. Second feather, fifth row (right side).

Figs. 4, 5, 6. Neck-mark of adult male hybrid between a male ring-dove hybrid and a female Surate turtle-dove. $\times 2$. Hayashi del., Nov. 1902.

Sire: *Streptopelia alba-risoria* \times *St. risoria-alba* (D 2). Dam: *Spilopelia suratensis* (Tt). Hybrid (F) hatched Sept. 25, 1899.

Fig. 4. This hybrid may be compared with *St. risoria*, *Spil. tigrina*, and *Spil. chinensis*, the latter being practically the same as *Spil. suratensis* in its neck-mark.

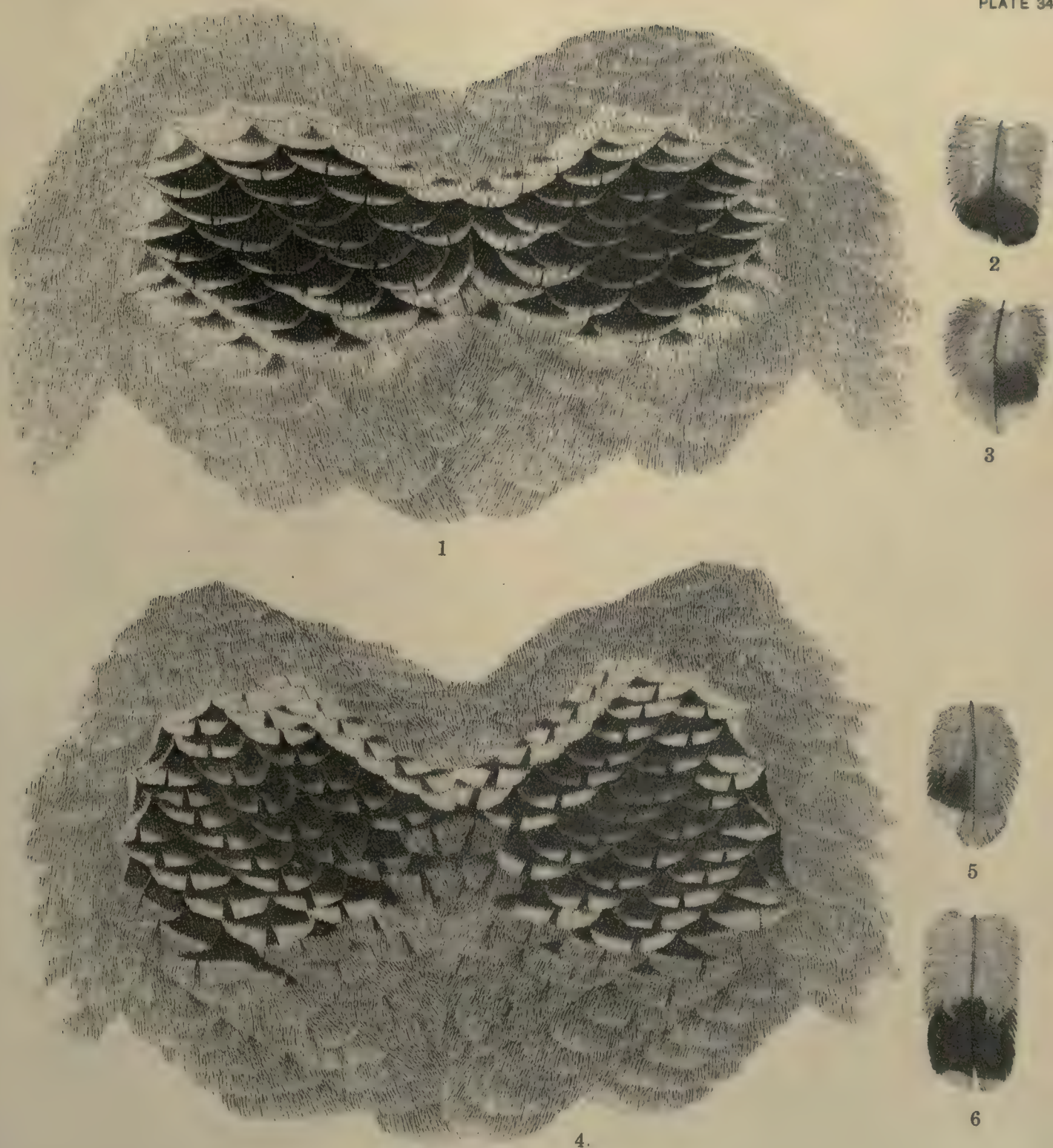
The rows are reduced in number and extent and the bifurcation is intermediate between the parents. It is in the middle region that the black ring takes most effect, some of the feathers tending here to lose the white tips. The coalescence includes about 2 rows plainly; i.e., about half as much as *chinensis*. This hybrid shown in color plate 25, fig. B; his dam in pl. 24.

Fig. 5. First of fifth row, right side. The right (front) half is gray with long vinous tip; the left web is differentiated and shortened, but only gradually.

Fig. 6. Eighth feather, fourth row (corresponds with fifth row in *T. chinensis*) left side. This shows full differentiation, and narrow white tips.



The Nicobar pigeon, *Calornas nicobarica* (figs. 1-6). From the Nicobars and Mergui Archipelago through Malay Archipelago as far as Solomon Islands (Salv., page 617). Selected feathers from *Columba guinea* (figs. 7-10) and from a *C. guinea* \times *C. livia* hybrid (figs. 11-14). Figures 1-6, \times 0.6, other figures natural size. Hayashi del., Feb. 1903.



Figs. 1-3. Adult male, *St. risoria* ($\frac{1}{8}$)-*Spil. suratensis* ($\frac{1}{4}$) \times *St. alba* ($\frac{5}{8}$) hybrid (T1). From egg of May, 1903. $\times 2$. Toda del., Apr. 1904.

Figs. 4-6. Adult male, *St. risoria* ($\frac{1}{4}$)-*St. alba* ($\frac{1}{4}$) \times *Spil. suratensis* ($\frac{1}{2}$) hybrid (F). Sire of T1 shown above. $\times 2$. Hayashi del., Nov. 1902.

a rather strong beak for their size. The differentiation on the side of the neck should be especially noted. It is a little like what we see in the passenger-ring-dove hybrid. A decided glistening is easily seen, and there is a well-marked differentiation of the feathers. A dissected or flat view of this mark is shown in pl. 32. Some five or six rows of the feathers are apparently stiffer and more scale-like than the rest of the neck-feathers. The two spots come near to meeting on the back, but they do not quite do so. The homing pigeon, like all the common pigeons, has a large amount of iridescence on the neck, and the ring-dove has the black collar as already noted. Now, between the black collar and the iridescence one gets the markings of this

This female was photographed after death by Mr. Hubbard (photo., Vol. I, pl. 9). The tips of the feathers are too evenly rounded (see drawing of feather from middle of sixth row). Nine rows show differentiation, metallic green. The iridescence covers 9 rows, diminishing rapidly on lower 3 rows, until, in the lowest or ninth row, only one or two feathers are weakly differentiated. The first feathers of the rows of the front-neck show a touch of iridescence. The limitation of the iridescence of these rows, the front-neck showing no iridescence except in feathers next to the posterior rows, brings this dove clearly between *Columba livia* and *C. fasciata*. *C. palumbus* stands lowest of the three, and next to the turtle-dove (*Turtur*). The same order applies to the reduced wing-bars.

FIG. 1. A feather from middle of sixth row (counting down). Middle part blackish gray, corresponding to black of ring-dove and turtle-dove. The wide tip shows blunt ends rather than tapered ends. $\times 2$.

FIG. 2. From front end of ninth row; the front web is vinous and is like others of the fore-neck, but the hind web shows weak iridescence and stronger barbs, though not so strong as in fig. 1. $\times 2$.



TEXT-FIGURE 4.—Neck-mark of adult female stock-dove, *Columba ænas*. Habitat, Western Palaearctic region to Eastern Turkestan. Natural size. Hayashi del., Aug. 1902.

hybrid, which, one might at first say, does not really resemble either parent. Examination will show, however, that the mark of the hybrid has all the fundamentals of the marks of both parents.

The nature and several modifications of this mark in the common pigeon and its allies (mostly *Columba*) are shown as follows: The African owl-pigeon (*C. turbata*) in text-fig. 3; the stock-dove (*C. ænas*) in text-fig. 4; the band-tail pigeon (*C. fasciata*) in text-fig. 5; the wood-pigeon (*C. palumbus*) in text-fig. 6; *C. leucocephala* in pl. 35; *Cal. nicobarica* in pl. 33. That the neck-mark of hybrids from two crossed members of the genus *Columba* is also⁶ an intermediate one may see in the

⁶ The hybrids previously described were of species belonging to different families.—EDITOR.

case of the *C. guinea* \times *C. livia* cross. The very peculiar mark of *C. guinea* (see text-fig. 7) is easily recognized in that of the hybrid which is shown in text-fig. 8; but in the latter the divided and bristling characteristics of the feathers concerned are less striking, and in some feathers there is no such division at all. This difference is recorded in pl. 33.

I may remark incidentally that the ring-dove gets its ring from the turtle-dove, and the turtle-dove has a "pair of spots" such as you see in the Japanese turtle-dove—six or seven rows of feathers with whitish or grayish edges and darker basal portions. In the homer \times ring hybrid referred to above the dark color of the male



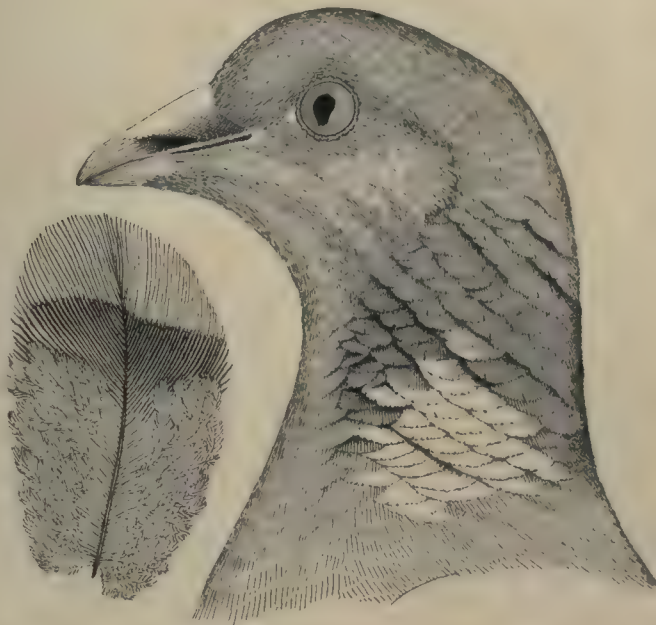
Eleven rows are involved in the neck-mark; the upper and lower rows are least differentiated. Some front feathers adjoining these rows are sharp-cut, stiff, and scale-like. The *white* is carried to the upper limit; in ring-doves it is carried to both upper and lower limits or edges of the mark, while in the wood-pigeon (*C. palumbus*, text-figure 6) it remains in the more narrowly differentiated area corresponding nearly with the turtle-dove spot.

TEXT-FIGURE 5.—Neck-mark of adult male band-tail pigeon, *Columba fasciata*. $\times 1.2$. G. A. Wilson del., 1900.

parent is reduced a great deal. There are here lighter edges to the feathers and dark-gray basals. The ring-dove and the turtle-dove agree in the number of rows of feathers involved in the neck-mark, and in every hybrid that we make between either of them and other doves that have iridescence we get the sort of blend of neck-mark seen in this homer \times ring hybrid. Adding another word to this digression, I may remark that the common pigeon and the passenger-pigeon, and all the rest of the group of pigeons, have probably been derived from an ancestor differing not very greatly from the Japanese turtle-dove. The simple condition of neck-ring and body-color, etc., found still in *T. orientalis*, represents a very natural starting-point for all the species of pigeons, although there are more than 500 species recognized to-day in this group of birds.

To show how this divisibility of specific characters works out when we carry it a little further, we will consider another pair of birds that I have worked with a little longer. The Surate turtle-dove (*Spilopelia suratensis*) is illustrated in colors in pl. 24. Attention may be especially called to the well-defined and peculiar character of the spots on the neck and to the central dark median streak of the wing-feathers. The feathers of the neck have a dark base and a white tip, which give the neck a sort of speckled appearance, white and black both showing, owing to the fact that each feather is split at the tip. The feathers are arranged in rows, and there is a larger number of rows than in the Japanese turtle-dove. The species *suratensis* has advanced considerably beyond the ancestral turtle-dove, both in the neck-mark and in the wing-feathers. In the Japanese bird is seen a simple

There are 11 rows of feathers in the neck-mark, as in the band-tail (*C. fasciata* text-figure 5), and some additional front feathers are affected. The light tips are seen on the lower 6 rows, which correspond to the spot on the turtle-dove. The tips are whitish or light buff, as the sample feather shows. A dark or blackish area follows the light tip; this corresponds to the dark area in feathers of turtle-doves.



TEXT-FIGURE 6.—Neck-mark of adult wood-pigeon, *Columba palumbus*. Natural size. G. A. Wilson del., 1900. Hayashi del. separate feather.

dark center with a light reddish edge. In *suratensis* the dark center has been reduced to a narrow median streak which is somewhat enlarged towards the end.⁷

The female Surate turtle of the illustration is the mother and a ring-dove⁸ the father of the hybrid shown in pl. 25. The first thing to notice concerning it is that its size is about that of the two parent species, which are nearly equal in size; the hybrid therefore agrees in this respect with both parents. The bird as a whole is considerably lighter than the mother, considerably darker than the father. But in order to see how neatly an intermediate character comes out, one may best examine the feathers on the neck. Here it will be found that the size of the spots is somewhat "reduced" as compared with the mother, but considerably "enlarged"

⁷ The form nearest related to *Spil. suratensis* is the Chinese turtle-dove (*Spil. chinensis*), which has completely obliterated this median streak; its neck-mark, like that of *suratensis*, covers many rows, meets with its opposite on the back of the neck, and is composed throughout of white-tipped, bifurcated feathers. (In text-fig. 10 these points are made clear, and also a comparison of this with other forms is made possible.—EDITOR.)

⁸ This bird was of "blond" color but an *alba-risoria* × *risoria-alba* hybrid.—EDITOR.

as compared with the father. Reference to pl. 34 will make this clear. The father's black ring is not more than half the width of that of the hybrid. Again, the arrangement of the feathers in rows can be seen more distinctly in the hybrid than in the mother, owing to the fact that the split at the tip of the feather is reduced to not more than one-half of what is seen in the mother. The interesting point is that the split does appear in the hybrid, and is of a size that would come fairly under the term intermediate. It remains to be noted that the size of the dark median streaks of the wing-feathers, in comparison with the maternal ancestor's spots, are very much reduced; but they are clearly visible in the hybrid.

TEXT-FIGURE 7.

Neck-mark of adult male guinea-pigeon, *C. guinea*. Natural size, Hayashi del., March 1903.

The neck-feathers, all around and up to the ear-coverts, are bifid (bifurcated at the tip.) See feathers and drawings on pl. 33, figs. 7 to 14. Iridescence is here very weak. The Chinese, the Surate, and tiger turtle-doves all have bifurcated feathers on the sides of the neck. These neck-feathers are arranged in *curved rows*, as can be best seen when the bird stretches its neck. This curvature of the rows is general in *Columba* and *Turtur*.



The male *risoria* × *suratensis* hybrid just described was next crossed with a white ring-dove.⁹ The result, as may be seen in pl. 26, was a further simple modification of the male parent's pattern—everything was made lighter and the size of the neck-spot still further reduced, and even the slight division at the tips of the feathers appears in some feathers. This is better seen in the flat view of the neck-mark in pl. 34. A sharpness of the extreme center (the vane) of the wing-feathers is all that remains of the median spot.

I later crossed this $\frac{1}{8}$ *risoria*— $\frac{1}{4}$ *suratensis*— $\frac{5}{8}$ *alba* male hybrid with a dark hybrid from a cross of the blond ring and the Chinese red ring (*St. humilis*). An adult

⁹ The white ring (*St. alba*) has been figured in pl. 8, and described in Chapters VII and XV.—EDITOR.

male of this latter species is shown in pl. 21, a juvenal male also in pl. 21. This species is considerably smaller than the ring-dove. It has a quite dark reddish color. The characters of the hybrid of this last-named cross, consisting of four species, are shown in plate 26. It will be observed that the *suratensis* streaks on the wings are still preserved. Indeed, they seem to be increased, but this is only *indirectly* so, due to the strengthening of the pigmentation as a whole which results from the admixture of the very dark *humilis*. I have two hybrids of this class, and both have the streaks on the wing-feathers quite as shown in the illustration.¹⁰

TEXT-FIGURE 8.

Neck-mark of an adult female hybrid (C) between a male *Columba guinea* and a chequered *C. livia*. Hatched May 19, 1901. Natural size. Hayashi del., Apr. 1903.

This hybrid resembles both parents in its form. The neck-feathers lie quite smoothly and the bifurcation is not apparent except on close examination. The feathers in the male parent hang loosely and present a rough, hackled appearance.

Plate 33, figs. 7 to 14, further assists in showing that the divided feathers do not cover so large an area as in the male parent; the divisions are not so deep, and are strongest on the sides and back of the neck, weakest in front.

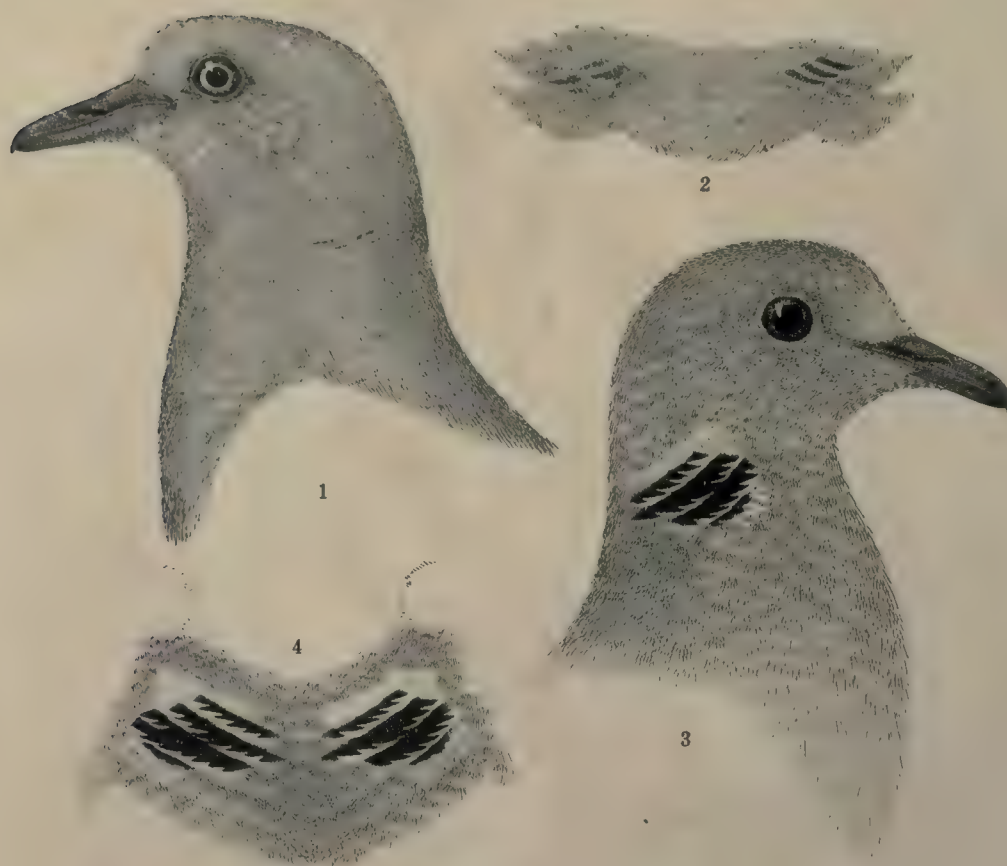
In the hybrid it is possible to see plainly the *rows* of feathers, which we could scarcely discern in the male parent. The skin around the eye is less in extent and smoother than in pure *C. guinea*. This hybrid was mated during two seasons, but produced no eggs.



I next took the offspring of this last cross (*i.e.*, the young of the male trispecific hybrid \times the *humilis* female and crossed it back with the white ring-dove. The result was the bird in this cage—the only one I have thus far obtained. It is rather light in color¹¹ and we can not yet see what the neck-mark is going to be, but one can see that the bird is of generally lighter color than its father (the mother was white; see table 154). As we go on with such studies, therefore, we find very definitely placed before us the fact that we can readily calculate what the result of crossing is going to be. We know definitely what the parents are and we can calculate mathematically—although I have never done such things myself—what the hybrid will be.

¹⁰ It should be said, however, that not all of this progeny were of this sort. The records (see table 154) show that 3 or 4 young (in a total of 12) died very early and that all of these were recorded as of "white" color.—EDITOR.

¹¹ This bird seems not to have been figured.—EDITOR.



TEXT-FIGURE 9.

1. Neck-mark of a juvenal *St. risoria* ($\frac{1}{4}$)-*humilis* ($\frac{1}{4}$) hybrid (K). Hatched July 11, 1902; age 4 weeks. Natural size. Hayashi del., Aug., 1902.

Sire, pure *St. risoria* (3); dam, *St. humilis* \times *risoria* (B 2). The feathers here are more closed, or cramped together, than seen in the flat view (2).

2. Neck-mark (flat) of *St. risoria-humilis* hybrid (K); same as above. Natural size. Hayashi del., Aug. 1902.

This mark may be compared with that of the juvenal (7 weeks) *St. humilis* seen in color in pl. 21, fig. B. There may be a lagging development of color in this hybrid as compared with that in the very dark *humilis*; the rate is probably nearer that of the ring-dove, since the hybrid is three-fourths *risoria*; compare also with fig. B, pl. 31.

3. Neck-mark of an adult male *St. risoria* (1) \times *T. orientalis* (13) hybrid (SO 1). Hatched May 9, 1904; alive Jan. 1915. Three-fourths natural size. Toda del., April 10, 1905.

This bird is shown in color, pl. 12. The position of the neck-mark is considerably influenced by the *T. orientalis* parent. Other details are better seen in the flat view presented in 4.

4. Neck-mark (flat) of the same hybrid as in 3 above.

The marks are somewhat smaller than in the Japanese parent; this is toward the ring-dove. The extent of the white on the feather-tips bears a similar relation to the parents.

Several accessory plumes are present within the neck-mark.

The outer portion of the second (lower) row of the left mark is divided into two rows. The division stops at about the middle of the row.

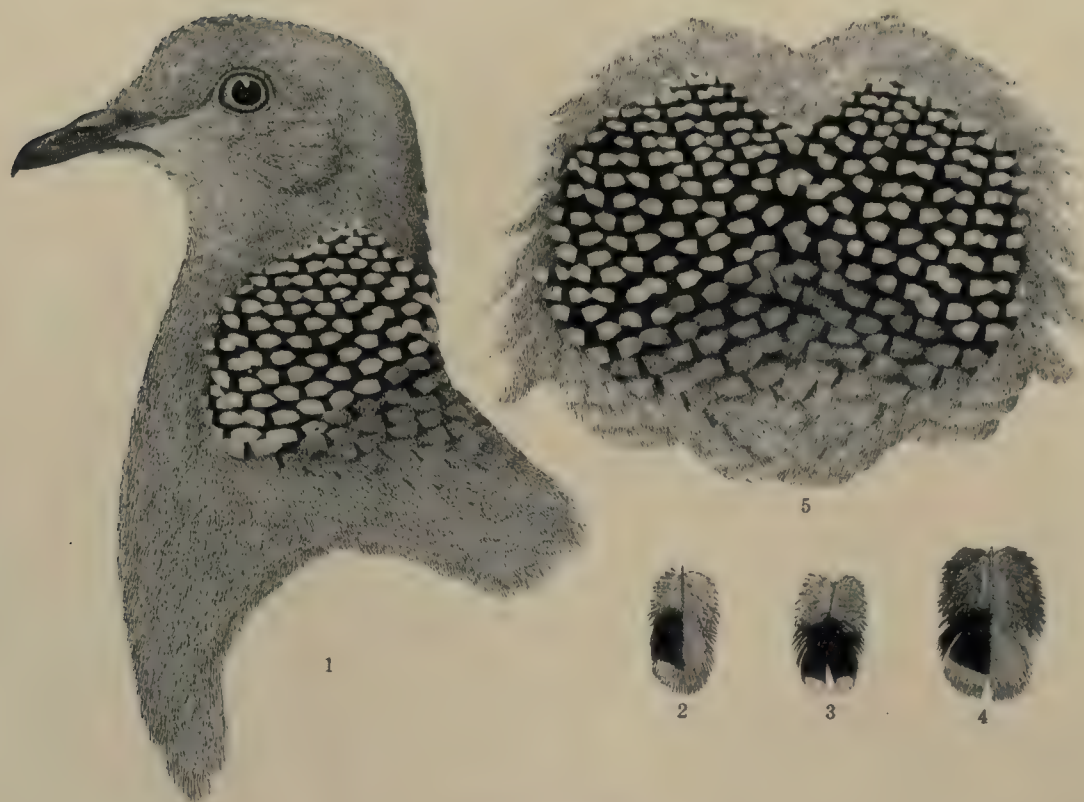


A. Adult male, *Columba leucocephala*. $\times 0.5$. Hayashi del., Mar. 20, 1903.

Habitat, Florida Keys, Bahamas, Greater Antilles; also Santa Cruz, St. Bartholomew Cozumel Islands, and coast of Honduras (Salvadori). Neck-feathers edged with velvety-black, very regularly cut and scale-like; green iridescent ("bronzy-green"). For color of male and female see plate 49, vol. I.

B. Adult *Columba domestica* \times *Turtur orientalis*. Hybrid. $\times 0.5$.

The feathers generally show light edges, though this is less marked than in *T. orientalis*. The neck-mark of hybrid shows more differentiation, stiffer feathers, and more distinct rows than in common pigeons, but less differentiation than in *T. orientalis*. Some iridescence is present, though this is difficult to reproduce.



TEXT-FIGURE 10.

Figs. 1-4. Neck-mark of an adult male Chinese turtle-dove. *Spilopelia chinensis*. Natural size. Hayashi del., Dec. 1902.

1. Side view of same bird as fig. 5, which shows both sides in one plane.

Evolution: We have to start with a form most nearly represented in *Turtur orientalis* of China and Japan. The centers of the wing-feathers there have the black rounded out full behind, leaving only the apical reddish bar, or tip.

In *T. turtur* of Europe, the dark center becomes reduced, ending in an angular point behind.

In *Spilopelia suratensis* (also bifurcated neck-feathers) the black is still further reduced to a dark mesial stripe.

In *Spil. chinensis* even the mesial stripe has departed, and the neck-feathers, tipped with white, are bifurcated. In these two last-named species the neck-feathers are not only bifurcated, but a larger number of rows are differentiated. Running back to *T. orientalis*, we find entire neck-feathers and fewer rows—6 down to only 3 or 4. The extension of the number of rows has also been accompanied by an extension of differentiation towards the mid-back of the neck, where the two spots plainly coalesce on the upper three or four rows.

2. First feather of fifth row (counting downward); right side. This feather comes on the boundary line and has black on the posterior web only; the front web is vinous, like the feathers of the mid-front of the neck and breast and has no bifurcation. The hind half is only touched with white close to the distal end of the black; elsewhere both webs are vinous-tipped.

3. Fifth feather of fifth row; left side. This row may be said to form the focal center of differentiation. The feather is widely bifurcated and the tips are white; the basal part up to the last one-fourth is black.

4. Seventh row; left side. Here the black becomes gray and the white vinous.

5. Neck-mark (flat) of same bird as figs. 1 to 4.

This figure shows the continuity of both spots in the mid-back region. We see here how the differentiated feathers pass gradually into vinous or brown, short tips into long tips, and bifurcated into entire. (For the color-scheme of the entire bird, in ink, see pl. 23, vol. I.—Ed.)

Now, when the blond ring (*St. risoria*) is crossed with a Chinese red ring (*St. humilis*) the hybrids obtained are intermediates of the two parent species. One of these hybrids, an adult male, is figured in pl. 22, a female in juvenal plumage also in pl. 22. Such hybrids are very measurably darker than *risoria* and lighter than *humilis*. They tend, too, to develop a little of the white edging or margin to the upper and lower limits of the neck-mark; this is towards *risoria*. In addition, these hybrids show a differentiation of color in the male and female.¹² These hybrids are fertile and give offspring like themselves. One of the offspring of a pair of such hybrids (an adult male) has been shown in pl. 23. The same bird shown in juvenal plumage (in pl. 23) will indicate the persistence of the blended body-color in the second-generation hybrids. One of the F₁ hybrids of the *risoria* × *humilis* cross was mated back to a male *risoria*. The result, so far as the neck-mark of the juvenal plumage of this latter hybrid is concerned, is recorded in text-fig. 9. The color has there made its appearance perhaps more slowly than it does in the *humilis* parent, which now represents but one-fourth of the hybrid's parentage.

When we cross the Japanese turtle-dove (female) with the common pigeon we invariably get a bird that has more gray and less red than the Japanese parent. The general characteristics of *T. orientalis* have already been shown in pl. 1. The

¹² The females seem to be lighter, the males darker (see Chapter XIII). The stenographic report of the remarks at this point is obviously incomplete.—EDITOR.

EXPLANATION OF PLATE 36.

Neck-marks of common turtle-dove of Europe, *Turtur turtur*.

Fig. 1. Adult male (?) *T. turtur*. × 2. Hayashi del., Sept. 1902.

Habitat: Western Palearctic Region in summer. In winter as far south as Shoa in Africa and as far east as Yarkand in Asia. Specimen received from Dover, England, 1902.

Very carefully drawn, giving every feather and following the natural form and arrangement. There are three main rows, of which the middle one (fourth) is the center. Two more above and one below show more or less differentiation. Eight dark feathers seen in second, fourth, and fifth rows; nine in the third, but ninth is not visible, except by spreading feathers a little. The neck has to be extended somewhat to show black in more than 3 rows.

Figs. 2-9 are of first and last feather of 4 rows (2 to 5 counting upward); right side.

Fig. 2. First of fifth row. A short, gray spot on the hind web; tip pale ashy or grayish-white.

Fig. 3. Eighth of fifth row. Two weak equal dark gray spots; tip of same color with neck.

Fig. 4. First of fourth row. Black on both sides, but more behind; tip incomplete, pale gray, and sharply cut.

Fig. 5. Eighth of fourth row. Black about equal on two sides; tip pale gray, passing to reddish; also longer barbs.

Fig. 6. First of third row. Blackish hind-half; tip pale gray, incomplete behind, sharp cut.

Fig. 7. Ninth of third row. Black and gray in front, black behind, tip pale gray with some vinous or red, and more sharp in front than behind.

Fig. 8. First of second row. Weaker black; the front web vinous gray. No sharp tip except on hind web; tip pale vinous gray.

Fig. 9. Fifth of second row. Very weak black on hind web.

Fig. 10. Adult *T. turtur*, from Dover, 1902. × 2. Hayashi del., July 1902.

Here we see only three black rows with a lower one showing a touch of dark when feathers are spread a little.

The upper (fifth) row has impure light tips, becoming more and more like neck-feathers in the mid-back region.

Fig. 11. The lowest degree of differentiation (smallest spot) found in a dozen turtle-doves from Dover, 1902. There are really only two well-marked rows; no tips normally differentiated, all showing more or less of the general color of the neck. The third row usually shows little or none of the black, and the upper row none at all except when spread out.

Fig. 12. × 3. The middle black row (third) is plainly the center. The fourth feather is here shown.

Fig. 13. × 3. First feather of third row (right) has black, plain behind; the tip shortened, pale grayish-white.

The seventh feather of third row (not separately figured) has less white-gray behind than in front; black on both sides.



Neck-marks of common turtle-dove of Europe, *Turtur turtur*.

neck-mark of the adult may there be noted. The common \times Japanese hybrid has the color-marks of the mother, but so washed out that one can hardly perceive that there is a distinct mark; still it is there, as may be seen by reference to pl. 35. The edges of the feathers are somewhat lighter than the basal portions; this, too, is in the direction of *orientalis*. On the neck one finds also an intermediate differentiation of the feathers toward the turtle-dove pattern in the number of the rows; and finally, the feathers of this region are found to have dark basal portions with slightly iridescent tips. These several characters, therefore, are easily divided in the first cross.

When we cross the female turtle-dove with the ring-dove (*St. risoria*) we get

TEXT-FIGURE 11.

1. Neck-mark of adult male *St. alba* ($\frac{1}{2}$)-*risoria* ($\frac{1}{2}$) - *T. turtur* ($\frac{1}{2}$) hybrid (J 1). Same bird as shown in colored pl. 37, fig. A. Age 11 months. Natural size. Hayashi del., Apr. 1902.

Sire: *St. alba-risoria* \times *risoria-alba* (D 2).

Dam: *T. turtur* (T I-B 1).

The figure shows the position, proportions, and intermediate nature of the neck-mark. Detailed description is given in connection with this mark drawn flat, figure 2.

2. Neck-mark of same bird as figure 1 and color pl. 37, fig. A; age 13.5 months. Natural size. Hayashi del., July 1902.

The mark comprises 5 rows of feathers:

First row (lower) shows but little of the dark color, which is mostly or wholly concealed when the head and neck are in the usual position.

Second row shows 9 black on right, 8 on left.

Third row (central) shows 7 black on each side.

Fourth row shows 7 black on each side; the two middle (dorsal) feathers are usually covered, but are here exposed.

Fifth row (upper) shows no black; in color these are midway between the spot-feathers and the general neck-feathers; i.e., the color is merely whitened a little, no black visible, and the differentiation is not so strong as in the other rows.

There are here two separate marks, nearly confluent in the third and fourth rows.



two different colors. One is a little darker than the other, and this is the main difference between them. All of the light ones turn out to be females, and most, at least, of the dark ones are males. In pl. 12 one of these males is shown; it is plainly intermediate in size, color, and neck-mark. The neck-mark is shown in flat and side views in text-fig. 9. Pl. 13 displays these characteristics, leaning somewhat toward *orientalis*, in a male hybrid of the reciprocal cross. The cross between the Japanese turtle and the blond ring-dove leads to a reduction in the extent of the neck-spots in the hybrid as compared with the Japanese species. There is also less white at the tips of the feathers. The spots extend a little farther back on the neck than in *orientalis*; they very nearly meet in some cases. All these characters, therefore, undergo division in a first cross.

When the Japanese turtle-dove is crossed with the white ring-dove the chief

difference from the preceding result is that the females, and the females only, are very much lighter in color (they are nearly white) than the females of the Japanese \times blond ring cross; while the males from the *alba* \times *orientalis* cross are probably fully as dark as *risoria* \times *orientalis* offspring. One of these nearly white female hybrids is shown in pl. 9; the color is very much reduced from the mother toward the white father. But some pigment is certainly to be found, and even this bird is, therefore, to some extent an intermediate. (The situation here is similar to that found in the "white" females of the *alba* \times *humilis* cross soon to be described. A reference to the additional illustrations which are used in connection with Chapter VII will show—see pls. 10 and 11—that in both sexes, from the Japanese \times white ring cross and its reciprocal, size, general coloration, and neck-mark all present themselves as intermediates, though some characters are more clearly so than others.—EDITOR.)

From the cross of the blond ring-dove¹³ with the European turtle-dove (shown in pl. 2) we get a hybrid that is again an intermediate of the two parents, certainly so in regard to the reduction of the spots on the wing and to the modification of the neck-mark. These points in the hybrid are clearly reproduced in color in pl. 37. (The neck-mark of the adult male hybrid is shown in text-fig. 11. These may be compared with the conditions normal for *T. turtur*, as shown more completely in pls. 2 and 36.) Then if I take this hybrid and cross it again with the blond ring, I get the wing-marks practically washed out; still enough remains of the distinctive dark color, however, to remind of the European turtle, and the neck-spots are once more reduced in the direction of the ring-dove. Two of these adult hybrids— $\frac{3}{4}$ ring-dove ($\frac{1}{8}$ *alba*— $\frac{5}{8}$ *risoria*) and $\frac{1}{4}$ European turtle-dove—are here reproduced in color, the lighter male in pl. 37, the darker female in pl. 38 (the juvenal neck-mark also in color in pl. 38; in addition, the flat neck-marks of an adult male and female are shown in pl. 39; and the juvenal neck-mark in position and flat also in pl. 39). These hybrids, represented in color, should be compared with their half-sister¹⁴ of pl. 38, whose mother was white ring instead of blond ring. Here it will be seen that the whiter dove reduced more strongly than did the brownish one the already once-divided body-color and neck-mark of the European turtle-dove. Carry the study still further by crossing the second hybrid ($\frac{3}{4}$ ring \times $\frac{1}{4}$ European turtle) with a ring-dove and we shall get nearer the ring-dove color and nearer the ring-dove size; the mark on the neck becomes quite small and of the ring-dove width, while the two side-spots are now found to touch each other on the back of the neck.¹⁵

Now, it would hardly be fair for me to stop here with my account, since in some crosses one can, apparently, obtain quite another result. When the male white ring is crossed with the female red ring (*St. humilis*) one gets sometimes a dark bird and sometimes a white one. In that cross I have obtained about as many white as dark. I have not carried this experiment far enough to know just what the results would be, but all the white young are females and most of the dark birds are males.¹⁶ One might say the white birds are like the father, while the dark birds

¹³An *alba-risoria* \times *risoria-alba* hybrid of blond color was the parent of the bird illustrated in pl. 37.—EDITOR.

¹⁴The brothers and sisters of this family show considerable variation, a fact made evident by reference to table 121. Several are not as light as the one illustrated.—EDITOR.

¹⁵No drawings of this final hybrid can be found.—EDITOR.

¹⁶See Chapter XII.—EDITOR.

are like the mother. But observation tells me not to be too confident in saying that the "white" bird is the exact reproduction of the father. In the first place, it is intermediate in size, and the white is the color that misleads us. When the bird is examined a little more closely it will be found that the tail-feathers have *some dark pigment*. The dark portion of the basal two-thirds of these feathers is the part that is very dark—almost black—in the blond ring-dove. It is evident, therefore, that we have the old pattern of the blond ring, together with some of its color, preserved here. I have not examined the other feathers of the bird microscopically or otherwise to determine how much pigment there is, but certainly there is some, as we can clearly see in the case of the tail.

This case, then, does not come to Mendel's rule, but may suggest something analogous to it. According to his rule the first hybrids are of one dominant color; the offspring of these hybrids divide, so that one quarter are like the one pure parent and another quarter like the other pure parent, and two quarters—or one-half—are like the first hybrids. In the case which we have just described the division into two colors is obtained in the first generation of hybrids, and the two colors are found to be closely associated with sex.

My main object in these remarks has been simply to present a few cases. The number of such cases that I might place in evidence could be much increased. The crosses I have made all tell the same story.

One thing, however, I would add in conclusion. According to Galton's law of ancestral inheritance, the two parents furnish, as is well known, only about one-half of the offspring, while four grandparents furnish a quarter, and the great-grandparents furnish one-eighth, and the sixteen great-great-grandparents would furnish one-sixteenth, and so on, until the offspring is represented as the unit, deriving these fractional parts from these different groups or grades of ancestors. The necessity of such a mode of reckoning lies in the fact that parents represent "mixtures." They are not "pure" to begin with. If a pure species is crossed it can be said that each parent contributes one-half, with nothing to do with other ancestors. That is, assuming that one has a pure species of birds—pure from one generation to another—one knows what he is going to get, namely, one-half of each of these species in each of the offspring. It is a very much simpler method¹⁷ than Mendel's or Galton's.

¹⁷ In the prefatory notes to this lecture Professor Whitman characterized his law, as elucidated in this chapter as that of "Pure or direct inheritance."—EDITOR.

EXPLANATION OF PLATE 37.

- A. Adult male *Streptopelia alba-risoria* × *Turtur turtur* hybrid. (J 1). Hatched May 15, 1901; age 10 months. Six-tenths natural size. Hayashi del., March 1902.

Sire: *St. alba-risoria* × *St. risoria-alba* (D 2). Dam: *T. turtur* (T I-B 1).

Note the intermediate neck-mark and the reduced dark centers of the general plumage.

- B. Adult male ring-dove ($\frac{3}{4}$) × common turtle-dove ($\frac{1}{4}$) hybrid (A 1). Age 10 months. Six-tenths natural size. Hayashi del., March 1902.

Sire: *St. risoria* ($\frac{1}{4}$)-*alba* ($\frac{1}{4}$). × *T. turtur* ($\frac{1}{2}$) hybrid (D 1); a brother to hybrid drawn in color, pl. 38, fig. B.

Dam: *St. risoria* (7).

The neck-mark and dark centers of feathers reduced a second time from the *T. turtur* characters by crossing with ring-doves.

This male fertile with a *Streptopelia risoria-alba* ($\frac{3}{4}$) - *St. humilis* hybrid.

EXPLANATION OF PLATE 38.

- A. Adult female complex *Streptopelia* × *T. turtur* hybrid (D 9). Hatched Aug. 10, 1904. Six-tenths natural size. Hayashi del., April 1907.

Sire: *St. alba-risoria* × *St. risoria-alba* × *T. turtur* (D 1). Dam: *St. alba* (O).

The neck-mark approximates to that of the ring-dove. The color of the general plumage of the sire is here much reduced.

- B. Adult female complex *Streptopelia* ($\frac{3}{4}$) × *T. turtur* ($\frac{1}{4}$) hybrid (E 1). Hatched Aug. 18, 1901; age 7 months. Six-tenths natural size. Hayashi del., March 1902.

Sire: *St. alba-risoria* × *St. risoria-alba* × *T. turtur* (D 1). Dam: *St. risoria* (7).

Sister to male (A 1) of pl. 37 B. Color dark.

The neck-ring here is continuous, but narrow in the back. It includes 5 rows of feathers; 3 rows make most of the ring (shown flat in pl. 39, fig. 4). This neck-mark comes nearer the ring-dove type than does the ring of the clutch-mate brother (E 2) whose neck-mark is shown in pl. 39, fig. 3.

- C. Juvenal male complex *Streptopelia* ($\frac{3}{4}$) × *T. turtur* ($\frac{1}{4}$) hybrid (H 2). Hatched Feb. 4, 1902; age 8 weeks, 3 days. × 1. Hayashi del., April 1902.

Sire: *St. alba-risoria* × *St. risoria-alba* × *T. turtur* (D 1). Dam: *St. risoria* (7).

In general appearance the ring-dove characteristics clearly predominate. Some influence of *turtur* is still seen in the shape and position of the neck-mark and in the light edge of the feathers that form it. Compare the neck-marks of a sister, fig. B, and pl. 39, fig. 4; of an adult brother, pl. 37, fig. A; and juvenal ring-dove pl. 31, figs. A, B, C; also with brother to sire, text-fig. 11.

EXPLANATION OF PLATE 39.

1. Neck-mark of juvenal male complex *Streptopelia* ($\frac{3}{4}$) × *T. turtur* ($\frac{1}{4}$) hybrid (I). Hatched July 14, 1902; age 47 days. × 0.6. Hayashi del., Aug. 1902.

Sire: *St. alba-risoria* × *St. risoria-alba* × *T. turtur* (G). Dam: *St. risoria* (6).

Compare flat view of both sides of neck in fig. 2. Note that feathers of the neck-mark are all edged with whitish-gray, after the turtle-dove pattern. In localization and in the form of the mark the influence of *turtur* is also evident.

2. Neck-mark (flat) of same bird as fig. 1. Age 47 days. × 2. Hayashi del., Aug. 1902.

The feathers are very distinctly edged with whitish-gray. The marks do not form a continuous ring behind, but this condition is approached much more strongly than in *T. turtur*.

3. Neck-mark of adult male complex *Streptopelia* ($\frac{3}{4}$) × *T. turtur* ($\frac{1}{4}$) hybrid (E 2); brother to female of fig. 4 below. Hatched Aug. 19, 1901; age 7 months. × 2. Hayashi del., March 1902.

This ring is broken in middle of back of neck; two elongated side-patches of black bordered above and below with white or whitish feathers. Ring of 5 rows of feathers, but 3 rows and a little of an upper row make up all that is seen. There is a lower row entirely out of sight; on the left, one feather of this row is pulled out far enough to show the dusky gray inner web. Note that the inner web of this feather is shorter than the outer.

More black is shown in the figure at middle of the back than is seen in nature, the feathers being turned to show the black. As the neck is generally held by the bird, the black here is concealed.

The black feathers are in greater number on the right side.

4. Neck-mark of adult female complex *Streptopelia* ($\frac{3}{4}$) × *T. turtur* ($\frac{1}{4}$) hybrid (E 1). Hatched Aug. 18, 1901; age 9 months. × 2. Hayashi del., May 1902.

The ring is continuous but narrow in the back. Five rows of feathers; three rows from the main part. A few feathers inside the ring-area show the white tip of the *T. turtur* grand-parent, but these are perhaps less evident than in the brother shown in fig. 3 above.



- A. Adult male, *Shreptopelia alba-risoria* \times *Turtur turtur*. Hybrid (J1). Hatched May 15, 1901; age 10 months. $\times 0.6$. Hayashi del., March 1902.
- B. Adult male ring-dove ($\frac{3}{4}$) \times common turtle-dove ($\frac{1}{4}$). Hybrid (A1). Age 10 months. $\times 0.6$. Hayashi del., March 1902.



- A. Adult female complex, *Streptopelia* \times *T. turtur*. Hybrid (D9). Hatched Aug. 10, 1904. \times 0.6. Hayashi del., Apr. 1907.
- B. Adult female complex, *Streptopelia* ($\frac{3}{4}$) \times *T. turtur* ($\frac{1}{4}$). Hybrid (E1). Hatched Aug. 18, 1901; age 7 months. \times 0.6. Hayashi del., Mar. 1902.
- C. Juvenal male complex, *Streptopelia* ($\frac{3}{4}$) \times *T. turtur* ($\frac{1}{4}$). Hybrid (H2). Hatched Feb. 4, 1902; age 8 weeks, 3 days. Natural size. Hayashi del., April 1902.

THE BEHAVIOR OF PIGEONS

POSTHUMOUS WORKS OF CHARLES OTIS WHITMAN

PROFESSOR OF ZOÖLOGY IN THE UNIVERSITY OF CHICAGO, 1892-1910; DIRECTOR OF MARINE
BIOLOGICAL LABORATORY AT WOODS HOLE, 1888-1908

VOLUME III

EDITED BY

HARVEY A. CARR, PH.D.

ASSOCIATE PROFESSOR OF PSYCHOLOGY AT THE UNIVERSITY OF CHICAGO

WITH A PREFACE BY OSCAR RIDDLE



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PHILADELPHIA

PREFACE.

Under other circumstances the subject-matter of the present volume would have been much increased; it would doubtless have included ample treatises on the voice and on comparative behavior and voice as indices of species relationship and of the direction of evolution in pigeons. If Professor Whitman's term of life had but been extended by the years necessary merely to write up his own completed work, it is probable that this would have sufficed for the production of important treatises on these two last-named subjects. But the condition in which these two divisions of his studies were left has not permitted an extensive presentation by the hands of others. The manuscripts treating of behavior in pigeons were, however, far nearer to a definite and final form. It is chiefly this material that is here organized and made available to others.

Though the present volume deals with behavior—a topic seemingly quite distinct from the subjects of the previous volumes of this work—the reader of the earlier volumes will not fail to find occasional strands of continuity between those and this the last. He will, in some cases, here find orthogenesis applied in the fields of instinct and intelligence and will note here again a limited but possible rôle for natural selection. He will observe that in pigeon behavior and intelligence, origins again seem to reveal themselves as improvements and modifications rather than as chance-wise saltations. Behavior and voice characteristics are noted—though they are rather scantily discussed—to blend, as did nearly all of the characters previously treated, and the studies here recorded on the reproductive cycle furnish illuminating data, not elsewhere available, as to the mechanism by which “overwork at reproduction”—as shown in the second volume—produces “weakened germs.” Though all of these elements of continuity are present, they are quite subsidiary in importance to the chief purposes of the volume, which are, to elucidate and interpret the behavior of doves and pigeons.

The completed manuscript, as it comes from the hands of Professor Carr, who has very generously and most conscientiously carried out the work of its preparation, can hardly give an adequate idea of the difficulties of his task. He merits much more than the thanks of all who may profit by this volume. Acknowledgments are made to the Open Court, and Ginn & Co.—publishers respectively of the *Monist* and of the *Biological Lectures*—for the privilege of republishing parts of two papers.

OSCAR RIDDLE.

EDITORIAL STATEMENT.

The material upon which this work on behavior is based is to be found, in the main, in 32 manuscripts varying in length from 1 to 40 pages. Professor Whitman's interest in the behavior of pigeons was evidently subordinate to his main tasks of a more biological nature. His work on behavior falls into two distinct periods. The first period includes the years 1895 to 1898. The greater number of the manuscripts bear these dates and consist of numerous short notes and descriptive material with some degree of topical arrangement. In 1897 and 1898 the author delivered lectures at Woods Hole on animal behavior; nearly half of these lectures were devoted to the pigeons. These two lectures were published in 1899, and from a perusal of the manuscripts it is evident that they were based to a large extent upon the studies made during the two preceding years. Soon after the above publication there appeared in the *Monist*, 1899, a short article on "Myths in Animal Psychology," a part of which again refers to pigeon behavior.

After an interval of 5 years the author's interest in behavior again recurs, and we find a second period of study covering the years 1903 to 1907. The manuscripts bearing these dates consist mainly of very detailed diary notes of the reproductive activities of several species of pigeons, and these, with one exception, were not summarized. From a remark in one manuscript (R 29) it is evident that at this time the author contemplated an extensive and intensive comparative study of the behavior of several species of pigeons. In August 1906 he delivered a lecture on "Examples of pigeon behavior" to a class at Woods Hole. This lecture was not published, and according to a note on the title-page it was delivered extemporaneously. This lecture evidently utilized data gathered during both periods of study.

A copy of Fulton's *Book of Pigeons* contains many marked passages, and on one of the fly-leaves was found in pencil a list of topics with their page references, evidently for the purpose of copying. As a consequence, the editor has felt at liberty to introduce several of these marked passages into the body of the present text; he has also incorporated those parts of Professor Whitman's two published articles on behavior which pertain primarily to pigeons. This has seemed advisable for two reasons: It brings together in one volume all of the author's material on behavior, and these writings furnish the reader the author's own interpretations and generalizations of the data of the manuscripts.

In organizing this heterogeneous material the editor has followed, in the main, the scheme made evident in various of the author's writings and in his final unpublished lecture. The material is thus grouped around the three main divisions: The Reproductive Cycle, Homing and Other Instincts, and the Relation of Instinct and Intelligence. In each of these divisions, as nearly as possible, the topical arrangement found in the manuscripts has been preserved. The first purpose has been to present a naturalistic account of the behavior of pigeons in Professor

Whitman's own words. In general, each topic is introduced by one or more paragraphs from one of his lectures or writings, or from his best-formulated notes. Further illustrations are then given from other notes, or by condensed excerpts, digests, or tables constructed from records which had not been summarized. The editor has refrained from additional comment, except for the purpose of making the account as smooth as was possible under the circumstances.

It has been thought well to utilize all the collected material. Selection by other hands than by the author himself might twist and perhaps distort his meaning. Although this procedure, in many cases, introduced considerable repetition of the description of the same type of behavior, it possesses the advantage of giving the reader all of the material for reference, and an appreciation of the care, the detail, and the completeness of the observations upon which these studies were based.

In this section on behavior we have followed the procedure of the preceding volumes of adding at the end of each topic the folder designation from which the material was taken. Such symbols as R 33, B 2b, C 7/17, SS 10, etc., mean that the material to which they are attached can be found in manuscripts contained in folders thus designated by the author. In these cases the text represents approximately the author's own words. The reader must bear in mind, however, that in many cases these manuscripts contain "notes" of the roughest sort. We have deemed it advisable to publish the material in its original form whenever possible, and as a consequence only grammatical and rhetorical alterations of the more obvious sort have been attempted.

For the fuller illustration of many topics, we have grouped together, in a running fashion, numerous statements selected from various parts of a diary record, and these quotations have been designated as "excerpts." At times this procedure has not been possible and we have summarized the pertinent data of a record in our own words and characterized it at the end as a digest or summary. In the construction of the five tables of statistical data we have been compelled to gather the material from so many divers sources that the use of any folder designation for each item was impossible. In these tables, and elsewhere, species and genera are often referred to by their popular names; but the names they bear in zoological classification have been added at such points and intervals as to leave no doubt as to the identity of the form under consideration. In the previous volumes of this work this feature is adequately treated.

Besides those editorial comments necessary to secure a continuity of account of the material, we have added at the end of several chapters a brief summary of the various facts and principles developed, and in Chapter IX we have attempted a summary and analysis of the data of the previous eight chapters, which deal with the reproductive cycle. In the main the reader will have no difficulty in distinguishing between the author's material and those parts representing the words of the editor. In order to avoid any ambiguity, however, the two materials have been printed with different type.

The entire task of compiling and editing Chapter X, Voice and Instinct in Pigeon Hybridization and Phylogeny, has been performed by Dr. Wallace Craig and Dr. Oscar Riddle. From the manuscripts and materials reviewed by them a number of excerpts have also been taken and utilized, under proper designations, in some of the other chapters. Dr. Craig, while studying pigeon behavior under the author's direction, made a practice of taking notes of his remarks during their conferences. From this material he has selected those observations closely related to the topics under discussion. This material has been inserted in the form of footnotes with the designation of "conv."

Any editorial criticism, evaluation, or interpretation of the results has been steadily avoided as far as possible. The single wish and hope actuating our labors has been to present this material to the reader in a serviceable form and to leave to him the final task of criticism and evaluation. Any evaluation of the material at the present time must consider the date of these manuscripts. The work began twenty-four years ago, two years before the appearance of Thorndike's monograph on "Animal Intelligence," which publication is generally regarded as the first experimental contribution to the subject of comparative psychology. Whitman's work was thus begun shortly after the appearance of the initial works of such authors as Romanes, Lubbock, and Lloyd Morgan.

I wish to express my appreciation of the courtesies extended me by the Station for Experimental Evolution of the Carnegie Institution of Washington, which have made this labor possible. Acknowledgments are also gratefully rendered to Dr. Riddle for his stimulating interest and suggestive help in the task.

HARVEY A. CARR.

UNIVERSITY OF CHICAGO, *January 1919.*

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THE BEHAVIOR OF PIGEONS

POSTHUMOUS WORKS OF CHARLES OTIS WHITMAN

EDITED BY
HARVEY A. CARR, PH.D.

VOLUME III

CHAPTER I.

THE MATING PERIOD.

The mating period refers to that part of the activities of the reproductive cycle which begins with courting and copulation and ends with the laying of the first egg. It embraces such activities as courting, copulating, and the hunting, acceptance, and construction of the nest. In the majority of cases its duration is six or seven days. The quest for a nesting-place begins one or two days after the initiation of the cycle and extends over a period of two to three days. The final acceptance of the nest-site is indicated by the beginning of nest-building. The construction of the nest continues for the rest of the period and may extend for several days into the incubation period. Copulation occurs intermittently throughout the entire mating period. These statements are based upon a very detailed record of the bronze-wing pigeon,¹ which covers a number of cycles. Excerpts from this record are herewith given in sufficient fullness to establish the above conclusions.²

First Cycle.—Dec. 10, 1905. The male goes to the nest-box and calls. He attempts copulation. On the 13th copulation was successful. It was attempted on the previous days, but there was no certainty of its completion. On the 14th the nest was accepted and there was some nest-building. The 15th and 16th were occupied with nest-building and copulation, and the first egg was laid on the 16th.

Second Cycle.—On Jan. 1, 1906, the male was ready to begin a new cycle and kept attempting to entice the female. The young bird died on the 7th. Courting and attempts at copulation occurred on the 8th, and the first successful copulations were noted on the 9th. The quest for a nest was begun on the 10th, and this activity, interspersed with copulations, continued until the 13th. Nest-building was noted on the 13th and the 14th. The 15th and the 16th were occupied with nest-building in the forenoon and copulations in the afternoon. The first egg was laid on the afternoon of the 16th.

Third Cycle.—On Jan. 23, both birds were courting, but there was no contact. On the 25th they were interested in courting and copulation. Courting was continued without contact on the next day, when the egg was deserted. The quest for a nest was begun on the 27th, and the nest was accepted on the 30th. Nest-building began at once and successful copulations were noted. No records were made for Jan. 31 and Feb. 1. Nest-building was noted on the 2d, and the egg was laid on the day following.

Fourth Cycle.—Courting and attempted copulation by the male were begun on Feb. 21. The young died on the following morning, and the day was occupied by courting, copulation, and hunting for a nest. The quest for a nest was continued throughout the 23d and 24th, and the final acceptance of the nest was noted on the 25th. Nest-building was recorded on the 26th and the egg was laid on the 28th.

¹ The author remarked to one of his students (W. C.) that the bronze-wing pigeons (*Phaps, Ocyphaps*), coming from the Southern Hemisphere, at first bred in Chicago in winter, but that they gradually changed their cycles until they bred in summer.—EDITOR.

² In this volume the largest print represents the words of the editor. The author's material has been printed in a medium-sized type. The small type has been used for the tables, notes, and other incidental matter. With this typographical distinction the reader will be enabled to identify the manuscript material.

Fifth Cycle.—The pair was separated on March 16. They were brought together during the mornings of bright days in order to secure photographic records of their mating behavior. Both were ready to mate and copulated whenever brought together. On Apr. 26 they were paired again and courting began immediately. Copulations and acceptance of the nest were recorded on the 28th; and on May 3 the first egg was laid. (Excerpts from R 33.)

THE BREEDING SEASON.

The manuscripts contain but few statements as to the normal breeding-season for the various species of pigeons. Table 1 has been compiled from the various

TABLE 1.—*The breeding season.*

Species.	Time of first egg of season.	Time of last egg of season.
Passenger (<i>Ectopistes</i>)	.....	8/29/96
" "	3/17/97	8/28/97
" "	7/14/98	8/ 7/98
" "	2/24/99	.....
<i>Geopelia humeralis</i>	1/13/06 (kept in house)	3/10/06
Bronze-wing (<i>Phaps</i>)	12/16/05 (kept in house)	5/16/06
White-face (<i>L. picata</i>)	4/11/07	6/ 2/07
Fantail (common pigeon)	.....	9/22/98
Crested (<i>Ocyphaps</i>)	7/25/96	.....
" "	2/ 4/97	5/22/97
" "	2/23/98	.....
Mourning-dove (<i>Zenaidura</i>)	3/24/97	8/ 4/97
" "	.....	8/ 8/98
" "	4/26/97	8/18/97
" "	3/15/98	7/30/98
" "	4/ 3/99	7/29/99
" "	4/13/00	7/12/00
Band-tail (<i>C. fasciata</i>)	2/11/03	.....
Wood-pigeon (<i>C. palumbus</i>)	1/ 8/01	.....
Satinette (common pigeon)	3/22/98	.....
Common pigeon	2/28/97	8/12/97
European turtle (<i>T. turtur</i>)	5/31/97	6/ 2/97
Blond rings (<i>St. risoria</i>)	3/12/95	12/23/95
" "	5/12/96	12/25/96
" "	2/ 8/96	.....
" "	1/28/97	6/ 4/97
" "	1/ 1/97	4/21/97
" "	3/ 5/97	6/ 8/97
" "	1/26/06	.....
<i>Zenaidura</i> ♂ × white ring ♀	1/ 8/97	3/10/97
" "	4/19/97	5/ 1/97
" "	6/16/98	.....
White fantail ♂ × ring-dove ♀	1/ 2/97	8/ 2/97
Common ♂ × ring-dove ♀	5/ 3/96	12/22/96
" "	1/23/97	8/22/97
Jap. tumbler ♂ × ring ♀	7/23/97	12/15/97
" "	1/20/98	2/21/98
Common ♂ × blond ring ♀	1/12/98	.....
Archangel ♂ × blond ring ♀	2/18/97	8/31/97
<i>Ectopistes</i> ♂ × ring ♀	2/24/97	6/29/97
<i>Ectopistes</i> ♂ × bl.-wh. ring hyb. ♀	1/26/97	8/15/97
" "	3/24/98	.....
Homer ♂ × blond ring ♀	3/11/97	5/ 2/97
" "	3/24/97	6/28/97
" "	6/ 5/97	8/ 5/97
Common ♂ × Jap. turtle ♀	9/ 6/97	12/20/97
Hyb. ring ♂ × homer ♀	6/16/97	12/18/97
" "	1/ 9/98	2/12/98
Blond ring ♂ × white ring ♀	11/27/96	.....
Red ring ¹ ♂ × blond ring ♀	12/20/00 (kept in house)	8/30/01

¹ Most of the species listed here, besides several others, have been drawn in color; these illustrations are given in Volumes I and II of these works.—EDITOR.

breeding-records, giving the dates for the first and last eggs for the year. Too much reliance may not be placed upon these data. Frequently the birds were not together early in the year, being mated late in the season, and as a consequence the date of the first egg is often not a true index of the beginning of the season. In some cases the records state that the birds were kept in the house, and this special care may have accentuated, in some pairs, the early development of the breeding impulse. As to the location of the birds, within or out of doors, there is no indication in many of the records. Frequently the pairs were separated and remated during the season for experimental purposes and, from the manuscripts dealing with behavior, no clue can be obtained as to the normal end of the season.¹ Further, experimental control and quasi-domestication (see following topic) may profoundly influence the duration of the season. Besides the table referred to above, the following comment is given:

During 1898 not an egg was laid by the passenger-pigeons until July 14. One was laid on July 15, and the remaining pairs soon became active. Why they began so late I do not know. They were brought to Woods Hole, May 25, and should have begun to lay in April at the latest. Possibly I fed them too much corn or too much in general. I ceased giving them corn about the end of June and lessened the amount of seed given. I do not know whether the laying was brought about by the change, but think it probable. In the season of 1899 the first egg from these birds was laid on Feb. 24, and the second on Mar. 1. Perhaps the late and small work of the previous year led to an earlier activity this year. The birds have been in the pen outside all winter, and it is the coldest winter experienced here for many years.

A mourning-dove \times ring-dove pair (*Zen. 5-C*) failed to fertilize eggs after August, the end of the regular season for the mourning-dove. Eggs were laid September 5 and 7, after the mourning-dove ceases normally to coo or care for eggs. (R 19, R 11.)

"Fancy pigeons generally show an inclination to mate together some time in the month of February; but much depends upon the temperature, as in very severe weather they will sometimes show no signs of doing so until March, whilst if it be mild some birds, if allowed, would go to nest in January."²

PROLONGATION OF BREEDING SEASON IN WILD PIGEONS.³

A pair consisting of a mourning-dove and a ring-dove⁴ was mated in April 1899. Three sets of eggs were produced and incubated by the end of August. Four sets of eggs were laid between Sept. 8 and Dec. 23, but all failed of development. The male continued to sit faithfully until the first week in November, but after that time he lost interest and performed his incubation duties very irregularly. It is noted that "this pair, although remarkably successful in fertilizing and hatching during the normal season, failed after August, *i.e.*, at the end of the regular season for the mourning-dove."

Another similar pair was also mated in April of the same year. Six young were raised by Nov. 1. A pair of eggs was laid on Nov. 15 and 17 and these were successfully incubated by the male up to Dec. 17, when they were removed. Another set of eggs was produced on Dec. 23 and 25 and the male exchanged faithfully until the removal of the eggs on

¹ A large number of complete and reliable data on this topic may be found in Volume II. The designations of pairs of birds—*e.g.*, *Zen. 5-C*—which are often appended in this volume, will enable those who care to do so to make further examination of the entire breeding record, as this is given in the previous volume.—EDITOR.

² Fulton and Lumley's *Book of Pigeons*, London, 1895, p. 35.

³ For a further reference to this phenomenon, see wood-pigeon, Vol. II, table 87.—EDITOR.

⁴ In these designations the name of the male is written first, that of the female last. The same order is used in referring to hybrids.—EDITOR.

Jan. 6, 1900. The male sat faithfully in October 1900, but two succeeding sets in November and December received no attention from him. In 1901 the sitting continued until December. It is noted that "the mourning-dove normally ceases to coo or care for eggs after Sept. 1. This late and regular sitting is remarkable, showing that the normal period can be prolonged as a result of domestication. Notice that this 'prolongation' is in a case where the male is unusually successful in fertilizing the ring-dove's eggs." (Excerpts from R 11.)

LENGTH OF MATING PERIOD.

The mating period¹ has a duration of 5 to 9 days; in the majority of cases its duration is 6 or 7 days. Apparently, no species differences exist. The average time for all cases after May is slightly less than that for the extremely early part of the season, but the difference is so slight that no confident assertion can be made. Table 2, giving exact data for several species, has been compiled from the various

TABLE 2.—Length of mating period.

Species.	Date of first egg.	Length of period.
Bronze-wing	12/16/05	6 days after mating.
"	1/16/06	8 days after first courting.
"	2/ 3/06	8 days after desertion of eggs.
"	2/28/06	6 days after death of young.
"	5/ 3/06	8 days after pairing.
<i>Geopelia humeralis</i>	1/31/06	8 days after breaking eggs.
" "	2/31/06	10 days after breaking eggs.
" "	3/ 8/06	7 days after desertion of eggs.
" "	4/15/06	7 days after death of young.
Blond ring ♂ × white ring ♀ . . .	4/ 9/96	6 days after mating.
Band tail	2/11/03	9 days after beginning nest.
Fantail	8/19/96	6 days after removal of egg.
"	9/22/96	7 days after ceasing incubation.
<i>Zenaidura</i>	4/21/97	9 days after mating.
"	4/26/97	5 days after breaking egg.
"	5/27/97	9 days after leaving young.
"	7/14/97	17 days after breaking egg.
"	4/ 9/98	7 days after breaking egg.
"	4/22/98	9 days ca. after breaking egg.
"	7/ 3/98	7 days after removal of young.
<i>Zenaidura</i> ♂ × white ring ♀ . . .	1/ 8/97	7 days after first copulation.
"	3/ 7/97	6 days after removal of egg.
"	3/18/97	6 days after removal of egg.
"	4/19/97	7 days after mating.
"	6/16/98	6 days after removal of eggs.
"	6/26/98	6 days after removal of eggs.
<i>Zenaidura</i> ♂ × blond ring ♀ . . .	11/25/99	8 days ca. after removal of eggs.
"	12/21/96	6 days after removal of eggs.
<i>Zenaidura</i> ♂ × ring dove ♀ . . .	12/23/99	6 days after removal of eggs.
<i>Ectopistes</i>	7/29/96	9 days after pairing.
"	8/29/96	6 days after first billing.
"	3/17/97	6 days after first courting.
"	4/ 4/97	8 days after removal of egg.
"	4/22/97	5 days after removal of egg.
"	4/28/97	5 days after removal of egg.
"	5/23/97	5 days after first courting.
"	5/30/97	7 days after removal of egg.
"	6/24/97	12 days after hatching of young.
"	8/16/97	7 days after pairing.
"	7/20/98	7 days after removal of egg.
"	7/27/98	7 days after removal of egg.
"	7/25/98	6 days after breaking egg.
"	7/31/98	6 days after removal of egg.
"	8/ 7/98	7 days after removal of egg.

¹ That is, the portion of each reproductive cycle during which copulation occurs.

records. The length of this period for females of various kinds, and variously mated, was given the following tests:

On Oct. 16, 1897, I removed the eggs from the following four pairs: (1) a male common dove and a female Japanese turtle; (2) a male archangel and a female ring-dove; (3) a male hybrid between a common pigeon and a ring-dove and a female black Japanese tumbler; (4) a male ring-dove and a female homer. On Oct. 23, or 7 days after the removal, all of the four females laid again. Thus a Japanese turtle-dove (*Turtur orientalis*) a ring-dove (*Streptopelia risoria*), a tumbler (*Columba gyrans*), and a homer (*Columba tabellaria*) all took the same time.

On June 10, 1898, the eggs were removed from four pairs which had laid between June 1 and 5. The four pairs were: (1) a male mourning-dove and a female white ring-dove; (2) a male mourning-dove and a female ring-dove; (3) a male hybrid and a female ring-dove; (4) a male mourning-dove and a female ring-dove. A second set of eggs was produced by each of these four pairs in six days after the removal of the eggs. The first egg in each case was laid at about the same hour (3^h 16^m to 5^h 05^m) in the afternoon of June 16; and the second egg at also about the same hour (7^h 50^m to 8^h 05^m) in the morning of June 18, after an interval of one day and two nights. The conditions of temperature and food were here the same for all. The time required for producing new eggs is sometimes only 5 days, but in colder weather it is sometimes 7 or 8 days.¹

On June 20 I removed the eggs from the following pairs: (1) a male mourning-dove and a female white ring-dove; (2) a male hybrid and a female ring-dove; (3) a male mourning-dove and a female blond-white hybrid; (4) two blond-white hybrids. These had laid between June 16 and June 19. Eggs were produced in three cases on June 26, six days after the removal. In the fourth case, the female persisted in sitting for several days after the removal, and the first egg was dropped on July 2, after a 12-day interval.

A pair of European turtle-doves (*Turtur turtur*) laid eggs on June 3 and 5 and the young were removed on June 26. The first egg of the succeeding cycle was laid on July 2, or six days after the removal of the young. (Summarized from R 19.)

Fulton, in his Book of Pigeons, p. 37, states that:

"Most pigeons² lay in from 8 to 16 days after being mated, some being what are called much 'freer breeders' than others. If a hen does not lay within three weeks of mating she should be separated from the cock for about 8 days and then returned to him, which will usually produce eggs."

INITIATION OF THE CYCLE.

The male usually takes the initiative in beginning the cycle, and the female may succumb to his advances at once or she may resist for some time. The female may also take the initiative and make advances, the male in the meantime being on the defensive. Either bird may thus remain in a state of readiness for a considerable period of time. If a pair, when ready, are prevented from mating by being separated, both birds may remain in a state of readiness for a month or longer. The primary sexual impulse seems to arise relatively automatically, and the succeeding activities of the cycle must normally await the reciprocal sexual activities of the two birds. Since the primary impulse may arise at different times in a pair of birds, this ability for either to remain in a state of readiness for some time is the means by which the two series of activities become synchronized with each other.

¹ After breaking up a nest the birds will often start a new cycle of copulations within half an hour.—EDITOR.

² Common or "fancy" pigeons are referred to here. The several species concerned in the preceding paragraphs and studied by the author, are more popularly known as "doves" of various kinds.—EDITOR.

The hypothesis that the sexual impulse arises relatively automatically with each bird does not imply that the two birds do not stimulate each other to any extent. While synchronization is normally effected, yet exceptions occur and the cycle may progress with one bird lagging a few days behind the other. Neither will a bird *always* remain in the first stage of readiness until the succeeding activities of the cycle are released by the reciprocal activity of the mate. Occasionally the cycle may progress to completion without the coöperation of a partner. These statements are illustrated by the following excerpts from the manuscripts.

A pair of *Geopelia humeralis* were put together on Dec. 23, 1905. On Dec. 26 it was noted that the male had every day shown some interest in nesting, but that the female did not seem to be ready. On Jan. 9, 1906, it was noted that the male had kept up his endeavors to interest his mate in a nest, but that so far she had remained indifferent. The first egg was laid on Jan. 21. Allowing 7 to 8 days as the normal time between the beginning of mating and the laying of the first egg, there was a period of about 3 weeks in which the female remained indifferent to the advances of the male. In the third cycle for this pair the female resisted the male's attentions for several days, while in the second and fourth cycles both birds seemed to be ready simultaneously.

In a bronze-wing pair the male took the initiative in all five cycles. The period of feminine resistance varied from 1 to 7 days. On the last cycle the pair was separated on March 16, 1906, just as they were beginning a new cycle. After a separation of 15 days they were brought together for a short time and courting began immediately, both birds seeming to be ready to continue the cycle. They were tested from time to time up to April 28, and both exhibited some interest in mating. They were now left together permanently and the new cycle started at once. Both birds thus remained in a state of more or less readiness for a period of 45 days.

A male mourning-dove (*Zen. 3*) was paired with a white ring-dove (*W 1*) on December 20. The female was eager to mate, and tried all possible ways to ingratiate herself in the favor of the male. He refused to have anything to do with her until 12 days later. On this date (Jan. 1), the female advanced to within a few inches and began billing her wings, bowing, cooing, and casting amorous glances. He soon began to be attracted, billed his wing, and showed that he was yielding. When she touched his head with her beak he repelled her by pecking because of fear. After these maneuvers were continued for 15 or 20 minutes he finally had the courage to take her beak in his, and thereupon the consummation followed quickly. I am quite certain that this was the first time that a union had taken place. On Jan. 5, *W 1* is still doing most of the courting. She is wonderfully persistent, taking no discouragement from any rebuff. On Jan. 20 I saw the male courting the female for the first time. This pairing was never successful. Although unions occurred, the eggs did not develop for lack of fertilization, and the male took no part in incubation. After 3½ months (of trial) he was given another female.

A young male fantail was paired on Aug. 13 with an impure fantail female which had previously mated and had been incubating eggs with another female. Two days later this female took the initiative and attempted to mate with the male. He was quite bashful at first, and although pleased with the advances, appeared to fear to let her come very near. He fought her off the stand and would not let her remain a moment in the cot. During the day he became more enamoured and by degrees suffered her to approach him, but always retreated at the moment she offered her beak, or else attacked her as if not yet quite sure that she could be trusted. This behavior continued throughout the day. On the following day, they were both coquetting and billing, and seemingly fully mated.

Three days later (Aug. 19) the first egg was laid, but the male did not begin to assume his duties of incubation until two days after the second egg was dropped.

The female of a blond and white ring-dove pair was nearly ready to lay and was inclined to mate. The blond male was savage and would not tolerate her presence; I was therefore forced to keep her in a small cage within his cage. On the following day he was still intolerant, but began to yield a little; he went to the box and called. She at once responded, went to him, tried to take the nest, and began cooing in her turn. The male endured this for a time and then drove her off. He next went to the opposite nest-box and repeated the same behavior with her. The white ring was patient and took all his abuse, and by night the blond finally became reconciled to her and condescended to sit beside her. (Excerpts from R 29, R 33, C 7/7, C 7/33, C 7/15.)

That females may take the initiative in mating is also evident from the fact that two females may mate and complete the cycle of nest-building, production of eggs, and incubation. (See topic on Pairing of two females, Chapter III.)

The completion of the cycle without the stimulus of a mate is illustrated by the following references: "Indeed a young and rank hen (domestic pigeon) will often lay, like a fowl, whether she be mated or not."¹

A male hybrid (mourning-dove \times ?) was paired with a California mourning-dove which was supposed to be a female, but which turned out to be a male also. The hybrid attempted courting during an entire month, but his advances were repelled. He then began the course of incubation on the floor of the cage. I soon saw by his behavior,—i.e., his refusal to move and threatening to peck at me—that he was actually engaged in sitting, although he as yet had no mate and no eggs. This cock had never been mated, and I was surprised to find him sitting with all earnestness, and that too on the floor, instead of in the nest-box. He went on sitting in this way night and day for a week, when I placed a couple of eggs in his nest-box and placed him upon them. He at once took possession and continued his incubation faithfully night and day for a week, when I placed the two birds in another pen outside of the house in the hope of securing a mating. (Excerpts from C 7/48.)

The lack of a proper synchronization of the two cycles of activities in a pair of birds is illustrated by the following note. For a more detailed account, the reader is referred to the record of pair X-W 1 in Chapter VII. The female W 1 had been with another female and had started on her cycle. When paired later with the male (X) she was nearly ready to lay. She at once made advances, but he was intolerant and resisted. He first began sexual advances about the time the first egg was dropped, and continued these for four or five days, while the female had passed through her sexual period and was engaged in the work of incubation. Only at the end of his sexual period did the male first take part in incubation; this was three days late.

This male (X) was evidently not in the spirit of sitting, and the presence of the egg did not stimulate him to the act. The decisive stimulus for such an act is thus not external but internal—probably a feeling which comes over a male *periodically*, and which he will manifest perhaps only if the external stimulus is also present. He has no impulse to sit. He is ready for making a nest and to accept a mate, but he requires *time to*

¹ Fulton, *op. cit.*, p. 35.

generate the impulse to sit. This impulse naturally follows the period of sexual activity, and he was still in the latter period.

In a brief note under the heading of "Sexual periodicity," it is remarked that "this (sexual periodicity) is apparent especially in Australian pigeons—speckled-necks, *Geopelia*, crested pigeons, etc. It is also marked in *Ectopistes*. The wood-pigeon and mourning-dove are good examples."¹ (R 20, C 7/15.)

MANNER OF DISPLAY.

The crested pigeon (*Ocyphaps*) has a very striking mode of display. The tail is raised and spread, and at the same time the wings are lifted just enough to show the whole surface. The bird bows and coos and strikes its feet, and all these movements are rhythmically combined in a very effective way. I noticed one of the *Geopelia humeralis* also performing by quite the same combination of movements. One of the *Geopelia striata* has exhibited itself in the same way, and with a peculiar coo. It is remarkable that two genera so different as *Ocyphaps* and *Geopelia* should have the same peculiar manners.

Darwin had a red tumbler which had a coo like the "laughter," and "the habit, to a degree which I never saw equalled in any other pigeon, of often walking with its wings raised and arched in an elegant manner." (See Darwin, *Animals and Plants*, I, Chapter V, p. 198.) I have seen this in a white fantail and in a black tumbler (Japanese), and also in a white and crested male dove-cote pigeon. It is quite common behavior. It is done usually when a male sees a female—or a male—whose attention he wishes to attract.

In giving the "coo" to the female, the male *G. humeralis* bows and follows the female with the tail raised to about 45 degrees or a little more, or nearly vertical, and spread, so as to show it to the best advantage. He uses it in the same way when trying to drive another cock. So the same behavior serves at least two purposes—one to frighten and the other to display.

I saw this display first in the male bronze-wing. This male was on the ground; the female was on the step-ladder looking down, as if about to fly down to the male. He noted this and began to display as if to attract her. He faced her, held his head on a line with his body, raised the wings without spreading or only a very little; raised his tail a little and held it spread; and meanwhile he stood actually on tip-toes and lifted first one and then the other foot, and so raised one side of the body and then the other in a way to exhibit his iridescence in different lights. This performance is remarkable—so well adapted to the end it serves. As the male wags his whole body slowly from side to side, he moves his head and neck back and forth from side to side. The lifting of the foot with the side raised, and then the other foot and side, right and left alternately, is done with an exquisite lightness of foot, as if the bird were overflowing with delight at the approach or the prospect of approach of his mate. I have seen this done by three males within a week or two, and by one of them several times.

A male mourning-dove (11) walks slowly and grandly along the perch, displaying himself to the female. She does not at once respond. He is anxious to mate, and shows no disposition to be aggressive, or to force her in any way. He sits at a little distance, watches her, now and then wags his wing at her, preens his feathers, inviting her to him. When he walks back and forth he raises the feathers of his back and rump, swells up his neck, and makes himself generally attractive. In strutting the wings droop a little, the primaries being held a little lower and not quite so tightly closed as ordinarily. The feathers of the back project backwards, rising above the level of the wing-feathers. The male sometimes flies to a point nearer the female, and as he alights strikes his feet against the perch, spreads his tail, and raises his wings a little, so as to show them and the tail at the

¹ For sexual periodicity in man, see Loisel, *Comptes Rendus*, Oct. 29, 1900.

same time. This combination of movements is often seen in male domestic doves. I noticed that when the female came to his call in the box the male winked (half closing and opening his eye-lids) and smiled (slightly opening his beak), expanding the lower mandibles so that we could almost see into his mouth. The California mourning-dove male performed in all these ways toward me when I answered his call.¹ (R 20, R 17, R 29, E 28, Em 7.)

STRIKING OR STAMPING.

A male *G. humeralis* is mated with a blond ring-dove. This pair is kept in a pen in the library. The male has just flown up from the floor to the perch beside the female. As he alighted he arched his neck proudly and gave the perch several quick strokes with his feet; I think both feet were used in alternation. The strokes could be heard very distinctly. The mourning-dove behaves in the same way when he alights beside his mate and sometimes he does this when both are on the floor. He runs up alongside his mate and gives these strokes as if in a burst of joy to be with her. The crested pigeon and the geopelias do this also.

A male mourning-dove flies from his perch to the nest-box and then back again near to his mate; each time, as he alights, he lifts each foot once, one after the other, and strikes it against the perch so as to make quite a loud thump, or rather two thumps in quick succession. It is done so quickly that it is difficult to see the movement, although the sound is quite marked. The crested pigeon strikes his feet in quick succession when spreading and cooing before his mate. I think the ground-dove of Florida does something of this kind, but I have only an indistinct recollection of it. *G. humeralis* does the same. *Leucosarcia* stamps once with each foot, one after the other, and holds its head down and its tail raised when it threatens to attack. This is sometimes repeated two or three times, the bird watching its antagonist to see if it shows signs of fear. If it does not take the hint, this may be followed up by a raising of a wing as if to strike. In presenting the wing, the bird moves sidewise up close to his antagonist before striking just like the crested pigeon. The stamping, the lowering of the head, and the raising of the tail seem here to be a modified form of the display of the crested pigeon.

A male *G. humeralis* began early in the morning to parade on the perch before the female; his performance settled into a repetition of jumping from one perch to the other, then stamping with his feet as he straightened up, and presenting always his beak to the female.

The stamping behavior of a mourning-dove (3) was observed. Each time that this male alighted on the perch he *struck his feet against the perch*; one foot being made to strike after the other. The two strokes were quickly made and were loud enough to be heard quite distinctly. At the moment of alighting he "swelled up" a little, held his tail somewhat expanded, and raised his head with an expression of pride in his appearance. The male mourning-dove No. 11 also *strikes* his feet against the perch as he alights, spreads his tail and raises his wings a little, so as to show them and the tail at the same time.

The behavior of the white-faced pigeons (*Leucosarcia*) in mounting reminds one strongly of the bronze-wing (*Phaps*) and of *Geopelia*; it is, in fact, essentially the same. The male white-face usually flew to a wide shelf (12 inches) 5 or 6 feet from the floor. He then struck his feet a few times in rapid succession against the shelf, so that one could hear the thumps plainly across the yard, even at many yards distance. When the male flew up and the female was already on the shelf the latter would straighten up and strike her feet on the shelf; then turn her back with the tail held down, the head up, and the tail spread just a little; then walk off, wheel around, and run up to him—stamping her feet. The male then would offer his beak, she would accept, and be fed with a few shakes,

¹ Further material on this and the following topic may be found in Chapter X.

then he would press his neck over hers, and, if she inclined, would mount. After waiting for a few moments on her back, he would dismount with a slap of his wings over his back. As he struck the shelf after dismounting he opened his mouth and gave a squawk somewhat like the bronze-wing, and would strut away from her. The pair would then bow, approach, strike their feet on the shelf, and repeat the mounting, often several times without a single union. (R 20, R 29, C 7/7, Em 7, Sh 8/13.)

CHARGING AND DRIVING.

The charging and driving of the female occurs when other males are present, as is noted in the subsequent topic on "Jealousy." The same activity occurs during the mating period in connection with courting, the quest for a nest-place, and in nest-building. It may also occur occasionally even during the incubation period. The purpose of the act is to force the female to the nest.

A male bronze-wing began to *charge* at the female, driving her quite vigorously. He evidently recognized her as his mate, but for some reason not clear he *charged* at her as if displeased at something. As soon as the birds were put together in the same cage the male began to *charge* the female, though they soon began their love-making and for two hours they kept up hugging, etc. The male began by charging, clucking all the time as he drove the female. It was more evident now that he wanted to start the female off *for a nest-place*. (Excerpts from fifth cycle, R 33.)

On January 13 and 14, 1906, the male bronze-wing was again seen driving the female. He would charge at her with his wings lowered a little and his back and feathers elevated, emitting a short cluck so rapidly as to leave nearly no interval between them. The notes and manner appear petulant. (From second cycle, R 28.)

The following description, covering the period from Jan. 29 to Feb. 2, 1906, refers to a pair of bronze-wings while seeking and building a nest (during the third cycle). On Jan. 29 the male is anxious to build a nest. The birds have been uneasy for 3 or 4 days, running along the side of the pen next to the window, as if they desired to get out. They have been in the nest-box several times, but have not yet decided to accept it and begin work. The male just now took to driving the female, charging at her, and giving her a spiteful peck, as if for some reason displeased with her. I then saw him do what I have not before noticed. He first charged at her; then lowered his head until his beak *touched and rested on the floor*, and with tail raised and slightly spread and wings a little raised, he gave plainly two little coos, in doing which he opened his beak at each note *without once lifting his beak*. The beak opens but little. The notes sounded like oo-oo, with a very short but distinct separation between the syllables—the first shorter, the second somewhat fuller and longer. This could be called the "driving coo," and is analogous to the cooing of a domestic pigeon. I later heard this oo-oo or cu-coo several times from two other males. It is, in fact, not a frequent behavior, but it occurs with all males in connection with charging and driving, whether for a nest or because the male is jealous of the presence of another bird.

On Jan. 30, the male is driving the female again. He gives the "short cluck" as he charges at her and walks about after her. The cluck is repeated slowly, except when he rushes at her, when it runs off hurriedly as a bubbling sound as before described. While following her up in this way, he sometimes resorts to the "driving coo." He has just given this twice. This time I feel sure that there are three notes and that the male is driving the female to find a nest as quickly as possible.

The notes sound sharper than yesterday, more as if beginning with *C* and could be represented thus *coo-coo-coo*, the second and third notes being shorter and closer together.

On Jan. 31 the male is again driving the female. He seems quite excited, holds his head high, the feathers of his forehead loosened so as to stand apart and out straight. The female tries all the while to get out of the cage in the direction of the window. The call described above certainly has three syllables, the second and third partially linked together.

On Feb. 2 the female has been sitting on the nest calling for straw and the male has been at work. The female left the nest and came to eat when I put food in their cage. The male at once became excited and began to drive her. He gave the cluck—the short petulant note described above, and followed it with the quicker rattling note as he charged and pecked at her. She seemed to understand his displeasure and returned to the nest without food. He then quieted and, after helping himself to the new food, returned to carrying straw. This shows what the driving clucks, the charging, and the coos mean. They mean, in this case, “go to the nest!”

The following case of charging occurred during the incubation period of the second cycle of the bronze-wing pair; it occurred about four hours after the second egg was laid. It was not connected with the initiation of a new cycle, as this did not begin until 5 days later. On Jan. 18 the male took his turn at nesting the egg; when he came off about 2 p. m., he charged at the female and even pecked her rather roughly twice. She soon went to the nest. (R 28.)

PERIODICITY OF THE DISPOSITION TO FIGHT.

The disposition to fight comes on in all pigeons at the time of mating and choosing a nesting-place. While fixing on a nesting-place, the male of a pair of homers (*C. tabellaria*) was pugnacious, fighting off other males whenever they came near. The disposition to fight and drive other doves away from the neighborhood of the nest becomes strong as soon as nest-building begins, and it is still stronger when the eggs are laid and after hatching. My young male passenger-pigeon (*Ectopistes*) while mated with a blond ring-dove bristled up, raised his wings, and scolded fiercely at the crested pigeons in the adjoining pen as soon as the first egg was laid. The wood-pigeons (*C. palumbus*) have been cooing and courting for at least 2 weeks, and the male drives off the 3 or 4 others of his own species from the nest. He seems to care little for the presence of birds of another species. A pair of white-faced pigeons (*Leucosarcia picata*) became savage, during the nesting period, towards the others of their own species, and I had to remove all of them; other species, however, were left with this pair. (R 4, R 11, Sh 8/13.)

In pigeons, as in many other birds, this disposition to resist enemies shows itself as soon as a place for a nest is found. While showing a passionate fondness for each other, both male and female become quarrelsome towards their neighbors. The white-winged pigeon (*Melopelia leucoptera*) of the West Indies and the southern border of the United States is one of the most interesting pigeons I have observed in this respect. At the approach of an intruder the birds show their displeasure in both tone and behavior. The tail is jerked up and down spitefully, the feathers of the back are raised, as a threatening dog “bristles up”; the neck is shortened by drawing the head somewhat below the level of the raised feathers, and the whole figure and actions are as fierce as the bird can make them. To the fierce look, the erect feathers, and the ill-tempered jerks of the tail there is added, moreover, a decidedly spiteful note of warning. If these manifestations are not sufficient, the birds jump toward the offender, and if that fails to cause retreat, the wings are raised and the matter is settled by vigorous blows.

The pugnacious mood is periodical, recurring with each reproductive cycle, and subsiding like a fever when its course is run. The birds behave as if from intelligent motive, but every need is anticipated blindly, for the young pair, without experience, example, or tradition, behave like the parents.

It seems to me that this mood or disposition,¹ although in some ways appearing to be independent of the disposition to cover the eggs, can best be understood as having developed in connection with the latter. It has primarily the same meaning—protection to the eggs—but the safety of the eggs and young depends upon the safety of the nest, and this accounts for the extension of this period to cover all three stages, building, sitting, and rearing.²

JEALOUSY.

The males of mourning-doves display as much jealousy as the common doves and the ring-doves, driving their wives at the approach of other doves. I have been amused at seeing a male guard his mate. In one instance I had placed a small cage with ring-doves within the larger mourning-dove pen. The male mourning-dove would drive his mate away from the cage to the farther end of the pen, then he would run back to the cage and peck at the ring-doves, and then back to his mate, billing her most affectionately. This behavior he kept up from day to day. Such behavior is a proof of his making a most decided distinction between his "mate"—a ring-dove—and other ring-doves.

In the case of a pair of homers I noted that just as soon as the nest-place was settled they both began to spend some time on the nest every day; copulations were then frequent (about a week before laying). A little later the male began to follow the female jealously and closely if other males were about. This male became so anxious to guard his mate that he would not, in many cases, stop to fight off a strange male, not even from his own stand; instead, however, he kept his eye constantly on his mate, paying no heed to another male, except to drive his mate out of reach of the latter.

The female bronze-wing, of a pair just beginning to build a nest, came to the floor at a time when several geopelias were strutting about in the adjoining cage; the male bronze-wing, for this or some other reason, tried to drive the female away. In doing this he drooped his wings a little, raised the feathers of the back, and charged at her, uttering a rapid note—a "cluck" rolled off rapidly. The charge was made several times and reminded me of similar charges that I have seen made by *Geopelia* males.

When a male dove sees another male in the act of soliciting or mounting his mate, he appears to understand instantly what the purpose is, and often makes frantic efforts to intercept the act, giving the danger signal in the loudest and most excited form and flying directly at the offending bird.³ (R 20, R 4, R 33, R 7.)

¹ This disposition to fight is further described near end of Chapter VI; see topic "Resistance to intruders".—Ed.

² Woods Hole Biological Lectures, p. 326.

³ If one male sees another male copulating, he immediately flies to knock him off. It is surprising the distance at which the bird will recognize this. If two birds make ready to copulate on the barn, a male which is on the roof of the house will immediately spy them and fly to prevent it. It is not that the intruder wishes definitely to take the place of the first male. His chief aim seems to be to knock the first male off. He then generally struts about and coos to the female, but only in a very general way. I have seen female birds act similarly, but the female's object of spite seems to be the other female, whom she attacks, pecking her head. Espinas says that even dogs do not seem to know when other dogs are copulating, and do not show jealousy. The birds certainly seem to understand what is going on. I think Espinas is wrong in regard to dogs. Dogs seem very peaceable in the matter, yet they seem to know what is going on. You commonly see half a dozen males after one female. Among pigeons, a bird sees and knows what is being done just as surely as you or I do. (Conv. 7/2/10, W. C.)

CHAPTER II.

THE MATING PERIOD (continued).

BEHAVIOR IN UNITING.

BEHAVIOR OF THE BRONZE-WING.

Preceding a sexual union in the bronze-wings (*Phaps chalcoptera*) the male begins bowing and at each bow touches the floor with his beak strongly enough to be heard distinctly at each tap. This bowing is solicitation and the female, if inclined, generally responds with bows in the same way, although not so energetically as the male. Then hugging or "necking," as we may call it, begins, each bird trying to get the upper hold with the neck so as to bear down upon the back of the neck of the other. In this play the male generally proves the stronger and the female submits to being held until he mounts. He holds her until he has moved sidewise up to a position which enables him to mount before she could well escape, even if she were disposed to do so.

The male of this species,¹ unlike other species I am acquainted with, does not dismount immediately on completing contact, but resumes his position on the back of the female, lowers his head, and utters a short cluck-like note several times, as he prepares himself for a jump with a single slap of the wings. The wings are lifted just a little and, as he suddenly springs, his wings are thrown up in such a way as to come together with a vigorous slap. When he lands on the floor he immediately lowers his tail and wings until their tips touch the floor, raises and arches his neck, and rushes with a strutting movement of his legs and with wide-open beak up to the female, or, in this rush, he may partly encircle her. She bows and so does he until their beaks have touched the floor several times; in some cases she then puts her beak into his, and they go through with movements similar to those performed by other species as a prelude to copulating.

The courting is all done on the ground. The male bows to the ground and the female answers in the same fashion. Sometimes the male jumps at the female, emitting a quick succession of threatening notes that roll off with the rapidity of a rolling *r*-sound. She retreats and he follows with several jumps, sometimes stopping to bow his head and to lift his tail and wings for a moment in display; he then rushes on after her.

The male mounts by a jump, then slowly takes his position. If the female does not respond to suit him he stands nearly still and slowly drops his wings until the tips nearly touch the ground, when he suddenly brings his wings together with a slap over his back as he jumps off, and at the same time emits an explosive grunt, arching his head and neck and strutting away with tail spread and trailing on the ground. Then he may return bowing, and hugging may begin on the part of both; but the male is the stronger and soon the female submits to another mount carried out in the same way; or perhaps the sexual union will take place, when the same vigorous slap of the wings is made and the male emits his grunt with beak wide open. This grunt is given as a sort of hearty growl by the wood-pigeon, and is accompanied by arching neck, contracting pupil of the eye, and two or three stamps with the feet on the perch.

I see again (1906) in the bronze-wings what I several times observed during the previous year. When the male has amorous propensities he bows before the female, touching the floor with his beak each time; this is followed by raising the head to nearly the height of usual carriage, or even a little higher. The male keeps on bowing and the female

¹ This paragraph and the five following ones were not written at the same time. They are given here in the order in which they were written.—EDITOR.

responds in like manner, if disposed to accept his advances. In his bowing the male slightly expands the wings, so that the feathers are arranged to sit to best taste. The tail is held at the usual height and width; but the rump feathers, including the upper tail-coverts, are raised, as they are when the bird is on the ground and bristles up (raises wings, etc.) to threaten an intruder. Then hugging begins, and if the male prevails, as he usually does, he bears down on the back of the neck of the female, moves up sidewise, halts a moment, then mounts neatly with an even hop of both legs. On the female's back he again halts all motion for 3 or 4 seconds, holding his neck very low, just over that of the female; while steadily holding his position he then gives a series of three or four or more guttural chuckles or muffled clucks or notes, beginning very low and rising gradually in each successive note until, with a much louder and explosive final note, he gives the dismounting jump and simultaneously a quick snap-like clash of the wings over the back. As he lands, he lowers his wings to his sides so that the tips touch the floor, and with spread tail also sweeping the floor, he rushes or circles with high-arched neck and wide-open mouth around the female. If the female prevails, as she did twice within a few minutes in the present instance, she goes through the same performance, only with every act reduced in energy and life. The male mounted four times on the particular occasion described here, but without reaching a sexual union in either case. This play is often carried on for rather long periods.

On the day following the behavior that has just been described I saw the male mount and carry the sexual act to conclusion. When the contact between male and female is effected, the male, unlike most or all other species, does not instantly dismount as contact is ended, but resumes his position on the back of the female, and then begins with the copulation notes previously described, finishing up with the leap, wing-clash, open-beak, strut, etc. This is a most theatrical performance. The male proceeds as if he foresaw and calculated each item with a view to closing the act with a grand climax. He is silent for a moment to make sure his feet are in place; he lowers his head to the front where it is ready for the final jump; he then prepares for a crescendo of chuckles, beginning the series with an inaudible one (seen in movement of throat), then a chuckle that is just barely audible, then one stronger, then another stronger still, and then the grand explosion, in which the chuckle expresses all the vim the bird can master, and which is cut short with an impetuous *w-h-e-w*, just as he springs with a sudden and loud clash of the wings to the floor, where the orgasm becomes complete, as expressed in pose, dress of feathers, sparkling of eyes, open mouth, and proud parade with trailing wings and tail. The male's recovery of position on the back of female is peculiar to this species, so far as I know.¹ Immediately after this copulation the hugging was renewed, and the male mounted and went through with all the usual performances, except that of contact. Then hugging began again, and the female was mounted with the usual behavior; then the male tried it again, but without contact.

At a still later date I was able to learn that when the male bronze-wing has mounted he makes the clucks slow and low as he reaches back and moves his tail from side to side until union is made; and that he then recovers his position and begins a "series" of clucks—one inaudible, a second just barely audible, a third a little stronger, a fourth and fifth increasing in force, a sixth and seventh close together, with an explosive seventh as he dismounts. There were seven clucks increasing in *force* and in *rapidity* to the last of the series.

After four unsuccessful cycles a pair (*I*) of bronze-winged pigeons were separated for 15 days in the hope of inducing regular work. After this period they were

¹ The male of *Geopelia humeralis* never recovers this position, but slips off the female the moment the union is effected, alighting on the perch, then bristling up and driving the female, as if angry with her.

brought together on bright mornings in order to secure photographs of their mating behavior. This behavior is described in the following additional records:

As soon as the pair was put together the male began to *charge* at the female, driving her vigorously. He evidently recognized her as his mate, but for some reasons not clear he charged at her as if displeased at something. The male later resumed these charges at the female, but they soon began their love-making, and for *two hours* kept up hugging, mounting, jumping, and strutting with mouth open, etc. The female often mounted the male; sometimes she came up to the male in a number of mounts, but towards the end the male was not so easily held by the neck, seemingly getting impatient of such play on the part of the female. On a later occasion the pair was active for an hour and then began to show less earnestness. The male began by charging, clucking all the time as he drove the female. It was more evident now that he wanted to start the female off *for a nesting-place*. The male carried through one copulation, but mounted many times besides, and the female succeeded in mounting only twice; of the two the male was plainly more active, and also less submissive to efforts of his mate to mount. The female, nevertheless, kept up her efforts, fruitless as most of them were. Her behavior is that of the male; it is merely *less energetic*.

COMPARATIVE BEHAVIOR.¹

The behavior of the geopelias in uniting offers one or two unique and distinctive features, but it is of greater interest for the several points of likeness which these birds share with the bronze-wings. The male of *Geopelia humeralis* (and other geopelias) mounts several times, clucking slowly each time until, with a sudden spring and a vigorous striking together of the wings over the back, he jumps off; he walks away slowly with tail spread, and after a few jumps he returns and takes the female's beak once or twice, mounts again, etc.; he continues this until the female is thoroughly aroused and ready to respond. After copulating, however, he shortens his neck and bristles up as if angry and drives the female away. *G. cuneata* does the same.

A female *G. humeralis* mated with a ring-dove does not flee from him after a union as she does from a mate of her own species. Her difference of action is due to different behavior on the part of the male. The male ring-dove allows himself, after a union, to be fondled by the female, and she expresses her joy by so doing. The male *Geopelia*, on the contrary, bristles up in a most savage manner and repels her love and drives her off, acting as if his pleasure had turned to displeasure and nausea.

The same slapping together of the wings over the back which is exhibited by these geopelias has already been noted as a common feature in the bronze-wing pigeon. It is, however, not so regularly seen in the bronze-wing; the male often jumps off with only a flirt of the wings and struts around the female. The bronze-wing also rarely takes the beak of the female (he does sometimes), but he often opens wide his beak as he approaches her. In pressing his neck over that of the female the bronze-wing acts much as *Ectopistes* does.

The behavior of bronze-wings in mating shows, therefore, some decided affinities with the geopelias. Most marked is the similarly repeated mounting of the female by the male; the lowering of the male's head over that of the female; the giving of a short note and the repetition of it while the male gradually lowers his wings preparatory to raising them and striking them together over his back as he jumps to the ground. A part of the behavior after jumping off is also similar in the two forms—the raising of the head, with arched neck stretched; the tail dragging on the floor; the strutting off and circling around the female; and at the same time offering the wide-open beak to the female. (R 28, R 33, R 17, R 1.)

¹ Further material on this topic may be found in Chapter X.

THE "JUMPING OVER" PHENOMENON.

This aspect of the mating behavior is nowhere mentioned in the manuscripts, although Professor Whitman had commented on it in conversation with his students and associates. The following account has been given by Dr. Riddle, who has since studied and analyzed this bit of behavior in terms of *degree* of sexuality in pigeons.

If one follows closely the mating behavior of many pairs of presumably normal doves it will be found that, in addition to the "mounting" by the male which is followed by a consummation of the copulation, both male and female doves occasionally exhibit quite definite motor activities of a similar or related sexual nature. The erotic male, for example, will sometimes *jump quickly over* the back of the female. In many such cases there is no attempt whatever to take the copulating position, but it seems to be the reaction normal to a male in a state of submaximal sex-stimulation; perhaps the reaction is associated with a weakly stimulated consort as well, for the latter usually thereafter stoops more intently, or otherwise invites the promised union with more ardor than before. The male, too, most commonly concludes his "jumping over" with a completed copulation.

It will be found, moreover, that an occasional female will *sometimes* mount the male. Possibly it is a sexually unresponsive male, with a lagging response, that is thus humiliated; but so far as the writer has observed, it is also *usually* a female that is *tubercular* that thus discounts the prerogatives of the male. In our experience, however, we have not yet seen a female "jump over" the *male*. This latter reaction seems, among the pure forms under consideration, to be a more distinctly masculine reaction than is that involved in the mounting which precedes copulation. And this, we shall see in a moment, is true once more among *hybrid* females when these are mated with each other. There it has been shown that *masculine* females will "jump over" other females when the latter assume strongly *feminine* attitudes.

The study of the sex-behavior of *hybrid* females has been developed into a method of arranging a group of sisters—proceeding from a sex-controlled mating¹—in a quantitative series of more and less "masculine" females. Concerning this situation we will, however, make only a short statement here. It has been found that females from a mating so arranged as to produce nearly all males from the stronger germs of the spring and early summer, and nearly all females from the eggs of late summer and autumn, are not equally feminine, as measured by their copulatory and "jumping-over" behavior. The first females of the season, and from the relatively stronger germs generally, function more often as males in copulating with their sisters hatched later in the season from weaker germs. These same females, from stronger germs, also readily and often show the "jumping-over" reaction, whilst this reaction has never been seen in many of the otherwise most feminine females; and it has been very infrequently seen in any of the more feminine ones.

BILLING AND "FEEDING" BY THE MALE IN MATING BEHAVIOR.

There is a widespread custom among pigeons to precede the sexual act by what is known as billing.² In this act the male presents an open beak into which the female inserts her own. This process is of longer or shorter duration, and varies greatly for the different species. During this process there is evidence for a regurgitation, by the male, of a small amount of food into the beak of the female,

¹ These matings are described in Volume II.

² This process is well known in the various varieties of domestic pigeons. The phenomenon is also referred to in the materials cited in Chapter X.

carried out in much the same way as both parents feed their young. This part of the activity of billing may also be spoken of as "feeding." That billing is not universal among pigeons, though it occurs in widely different groups, is indicated by the several observations which follow:

Bandtail pigeons (*Columba fasciata*) approach each other by the usual method of billing the wing, but the female does not insert the beak, and the male does not offer her an opportunity. The preliminary movements are slow in these birds. The male mounts without offering the beak and slowly takes his position, while the female as slowly aids by raising her wings to support him. The male then finally pitches back rather suddenly and dismounts after a flash contact. As he alights beside her he raises his head and *points his beak upward* for a moment in the expression of his pleasure.

I have seen a male mourning-dove (*Zenaidura carolinensis*) take the beak of his mate in his mouth and give one or two quite quick and vigorous shakes. This bird then mounted and finished the act in a moment's time—much quicker than in any other species known to me except the small ground-doves of Florida. The rapidity of the mourning-dove's movements in these acts was in striking contrast to that of the passenger-pigeon (*Ectopistes*). The mourning-dove rapidly bills his wing, shakes his feathers, and offers his open beak, gives a few jerks when it is accepted, and then finishes in the usual way.

The male of *Geopelia humeralis* mounts, jumps off, takes the female's beak once or twice, mounts again, etc., until the female is thoroughly aroused and ready to respond. The male of the bronze-wing seems rather rarely to take the beak of the female, but often opens wide his beak as he approaches her. (Sh 30/13, C 7/7, R 28, R 33.)

The male sometimes feeds the female during the billing activity. This phenomenon was recorded three times in the bronze-wing records. We shall quote the references and then give the detailed circumstances under which the act occurred:

The female was sitting on the ladder 3 feet from the ground. The male was 5 or 6 feet away on the ground. He bowed and called; she flew down, ran up to him, and put her beak in his. The male fed her with an up-and-down shake; after billing from one side of his beak the female shifted to the other side. On the following day the male called the female from the ladder. He opened his beak and she inserted her beak, first on one side and then on the other. He apparently fed her; at least he went through the motions of doing so.

On Jan. 5, at 2 p. m., I saw the male walk off on the perch and fly to the floor, where he then began bowing profusely; the female put her beak in his mouth, and the male gave a few very vigorous shakes, during which the rattling of the contents of his crop could be heard. The female after accepting this feeding from the male at once returned to the nest.

At 7^h 30^m a. m. on Jan. 26 this female bronze-wing was on the floor. The male bowed and the female ran to him and the two began hugging. The female soon reached out her beak to that of the male, feeling about as if she wanted to be fed. Then the male opened his beak and received that of the female, and fed her with a few shakes. Hugging by the male occurred for a moment. The female again at once reached out her beak to be fed, and the male again fed her with a few strong shakes. This was repeated for a third time, and shortly afterward, without any coitus, the female went to the nest. (R 28, R 33.)

The circumstances under which the first of these "feedings" occurred are not definitely stated, except that the act was connected with their courting. Judging from the context, this case probably occurred during the incubation period, and

hence it was connected with the premature beginning of the next cycle. The description was given under the caption "The male feeds the female."

The second case occurred during the latter part of the first cycle. The male had finished prematurely his incubation period on January 1, 1906, while the last egg was hatched on January 4. In the meantime the male participated in the incubation perfunctorily and half-heartedly and spent much time in attempting to entice the female to a new cycle. When the eggs were hatched the male did not feed the young nor take his turn in covering them. The female was thus forced to do double duty in both feeding and covering the young. The young birds died for lack of proper care, and a new cycle was started immediately on January 8. The feeding occurred on the 5th, the day after the second egg was hatched. The motive of the female's behavior in accepting food could well be hunger and not sexuality, for she had been doing double duty in nesting and feeding for several days, and she did not respond to the sexual advances of her mate until three days after the event in question. Since the male normally participates in the feeding of the young, one might suspect that this act of feeding his mate represented the onset of this normal impulse. This interpretation is improbable, however, because the male's conduct was not normal. He had finished his incubation period and had started on a new cycle four days previously. Under these conditions the feeding impulse does not develop, and, moreover, he gave no sign of this tendency in his behavior towards the young. The act seems rather to be connected with his sex behavior.

The third case of feeding occurred on January 26, *i.e.*, on the tenth day of the incubation period of the second cycle, and 7 to 8 days before the eggs were due to hatch. Both birds had been engaged in courting and attempts at copulation for three days previously, and the eggs were definitely deserted; the third cycle started on the day the act occurred. The act was thus connected neither with hunger nor with the impulse to feed the young; it occurred in the midst of their courting activities, so that in both birds this behavior was undoubtedly in some way connected with their sexual activities.

During the fifth cycle of this pair it was noted in connection with the detailed description of their uniting behavior that "there was no *feeding*¹ this time." This cycle was begun after a lapse of about 40 days.

THE QUEST FOR A NEST.

When ready to find a place to nest many pigeons may be often seen to raise their wings a little as if to fly, and while the wings are thus raised they are wagged or moved a little and the head is stretched forward. This is common conduct in *Ectopistes* when it is ready to seek a place for a nest. The same behavior has been seen in stock-doves (*C. ænas*), and I have often seen the same in common pigeons. In this state the bird seems uneasy, is ready to fly, but is undecided where to go; it executes a flying movement which is held in restraint, and which is sometimes only a sort of vibration of the wings while closed and held a little loose. At other times the wings are more or less extended, as if for flight.

¹ This statement probably means that there was neither billing nor feeding.—EDITOR.

It was abundantly evident from the following behavior that a pair of passenger-pigeons was prepared for the second reproductive cycle. They flew several times against the wire of their cage, and seemed to wish to get out in order to find a new place for a nest. The behavior was the same that I had seen in the blond ring-doves (*St. risoria*) at such times. Two days later these passengers were very active, but not yet decided where to place the nest. The male was especially active, taking the lead in the search. He kept alighting on a small tree inclosed in their large pen, and here he would put down his head and call the female. I repeatedly saw this pair flying about in search of a nesting-place. I note, too, that when the male flew back and forth he called to his mate *while on the wing*. These birds stoop as if to fly, and often, before starting, raise and lower the *closed wings* in the rhythm of flight. Here the flying movement is held in check by the knowledge of the bird that the window and wire were not pleasant things to fly against.

A pair of blond-rings (*E*) were very restless this morning and both are now trying to get out of the cage and are evidently intent on finding a place for a nest. These birds stood before the door and kept flying up, as if wishing to have the door opened. They finally went to the old nest and settled down there as a last resort. It is remarkable how strong is the instinct *to place the new nest in a new locality*.

A pair of old bronze-wing birds were two or three days in settling on a nesting-place in the same box formerly used by them. They ran back and forth on the floor as if desiring to get out, and on the next day they tried the box, but were not content. Their contentment was finally fixed, as they could do no better. They were fully decided and at work in the box two days afterwards. The eggs laid here, however, were deserted. On the day following their desertion the birds were both uneasy, running back and forth to get out of the cage; they were evidently hunting for a new nesting-place. On the next day they were beginning to accept the old nest-box again, but they did no real work. A little later these birds again began the hunt for a nesting-place; both ran back and forth to get out of the cage, and when the male went to the nest-box and called, the female flew to the perch and answered. They were not satisfied, however, and soon left the box. Three days later the female was on the nest calling for straw, but the male was running about on the floor trying to get out; apparently he had not yet decided on a place for the nest. An hour later the male began carrying straws and the nest-building was continued industriously thereafter.

A female blond ring that has a crested pigeon for a mate to-day acted like a dove that, after rearing young, is looking for a place at a distance for a new nest.¹ She flew back and forth in a very uneasy manner, trying to get out of her pen into the large room in which it stands. On the following morning the female was driven about by the male, who then seemed uneasy and evidently looking for a place for a new nest. This male tried very hard to get out of the pen and to interest the female, but she appeared comparatively indifferent. (R17, SS4, C7/17, R33, R19.)

NEST-BUILDING.

ON THE METHOD OF NEST-BUILDING.

The details of the activities connected with nest-building, as this was observed in a pair of bronze-wings, may be had from the following record made while nest-making was in progress: The male bronze-wing has just carried a straw, delivering it by jumping onto the female's back and placing it near her beak. A second straw has just been

¹ It is natural for the pigeons to take to a new nest for the second brood. This is especially true of the common pigeon. But sometimes a bird, more shiftless and indolent than usual, will lay in the old and filthy nest. Many of the species use two nests. Apparently they want a *clean* nest as well as a new, fresh situation. The male common pigeon, while his mate is sitting, generally seeks another room in the cot for his roost; and when it is time for the second brood he leads the female there; other pigeons have been driven away, and the place is ready for her to nest. Probably the common ring-dove uses two nests naturally; and so do many other species. (Conv. 6/24/08, W. C.)

delivered in the same way and now again a third in the same manner. When the male approaches the nest, the female continues her calls but bows each time and waves her closed wings slowly up and down as if welcoming her mate. The female has turned in her nest so that she faces in the opposite direction, and the male jumps on her back in delivering. She has again turned, so that she now faces him as he arrives with her tail at the corner of the cage; in this position he delivers without mounting, but he tries to side up to her so that his head may point in the same direction as hers. In other words, he seeks to deliver from above and behind, but omits the mounting, owing to the awkward or unfavorable position which he can not well meet by mounting.

On the following day I find that the male is still taking hay to the nest. Yesterday I noted one case in which the female changed her position, so as to have her tail at the corner of the cage and her head at the opposite side, so that she faced the male as he arrived. I have just seen the taking of this position repeated and the male make two deliveries. In the first instance he jumped onto her back and turned, placing his body parallel with hers, and then placed the straw under her breast. In the second case he jumped on her and stood at nearly right angles and placed the straw under her wing; the female here turned her head to take the straw. The male's behavior in jumping onto the back of the female is very probably a necessity in nature, since the male bird would usually not find it possible to deliver otherwise; besides, his taking this position serves to test the strength of the nest and of its support, and helps to keep the straws in place and well pressed together.

I now note that when the male flies to the perch he stands still for a few seconds, about 3 to 5 seconds, as if to see that there is no danger of discovery before he visits his mate. Wild birds generally are cautious in this way; if they were otherwise their nests would be easily discovered by enemies. I have found that the male passenger-pigeon also delivers his straw or twig by mounting on the back of the female and placing it in front of her in the place most convenient for her to receive it.

All pigeons, so far as I know, carry but *one straw* at a time; the sparrow, on the other hand, loads itself up with as many pieces as it can hold in its mouth, and thus saves trips to the nest. The sparrow's method is the more economical—less wasteful of time and energy. What an interesting step—for a bird to learn to take many instead of one at a time. In this simple difference of method we see a wide difference in intelligence. It is not supposable that the step could have been first taken by the sparrow as a mere accident (without the aid of the intelligence above that of pigeons), and then confirmed as a general habit through natural selection of the individuals who were lucky enough to adopt it. The first impulse to pick up several straws instead of one implies greater intelligence, and this superiority would be favored in the struggle for existence, in a thousand different ways, of which that here considered is but one.

The pigeon often shows great stupidity in gathering straw. If it happens to pick up a stray straw on the side of the nest, instead of turning right around and delivering it, the bird will often first fly off with it, as if in search of a new straw, and then fly back and give it to its mate. I have often seen such performances. If the pigeon drops a straw in flight to the nest it never stops to pick it up, but goes off again to find another. If a sparrow drops a part of its load of straw it will often try, while still holding fast to what remains, to catch it in mid-air, and will follow it to the ground if need be to recover it. Here again the sparrow displays intelligence quite above that of the pigeon.

ON THE PURPOSE OF NEST-BUILDING.

The following instance throws some light on the nest-building instinct: A pair of young common pigeons only 30 days old were kept in a pen in my library. They occupied a small nest-box with a nicely saucer-shaped nest. In this nest-box they were hatched and

reared. The box was kept on the floor of the pen. To-day I removed the box from the pen, leaving only the hard floor for the birds to rest upon. This afternoon I noticed that they were trying to rest on the floor in the place where the box had been. They found the floor did not afford them the comfortable bed which they had had in their old nest, and they showed by uneasy actions that they realized that their bed had not the proper shape. One of the two young then began the nest-making movements with its feet and legs, as if to work out a more comfortable place. The act was repeated several times under my eye at a distance of only 2 feet, so that I could see plainly that the motions were exactly those of an adult bird in preparing a nest.

In this case we see one of the more essential combinations of actions involved in nest making performed by a young bird that has certainly never learned the trick from old birds. The bird doubtless remembered its easy nest, and sought to make its bed a nest-like concavity. It is *instinct* and *intelligence*, for having just a while before enjoyed something better, the bird was not satisfied with a plain hard floor. The discomfort would probably not have been felt had the bird been accustomed from the first to such a surface. The cause of the action may have been of the same nature as that which stimulates the old bird in nest-making. *The purpose of the bird is to make her place easier*, and she does not think of the need of a hollow bed to hold eggs. The two needs—her present comfort and the future need of the eggs—are identical and are satisfied by the one act. The future purpose is not in the bird's mind, but it is this need that the observer usually thinks of, wholly forgetting the need that the bird thinks of. (R 33, SS 4, R 7.)

NEST-CALL.¹

THE PURPOSE OF THE NEST-CALL.

The nest-call is given very frequently by both birds throughout the entire mating period. It may be given from either the nest, the floor, or on the wing. The purpose of the call is evident from the following disconnected excerpts gathered from various records. The call also occurs throughout the incubation period. (See Voice, Chapter V.)

A pair of bronze-wings were beginning to prepare for a nest, the male taking the lead in going to the nest-box and calling. The female took her place in the nest and called for the male to bring straw. The female was in the nest and calling, while the male was on the floor looking for straws. The many calls of the male evidently indicate that he has a sexual inclination. The male calls the female to a new nest-making, absolutely indifferent to the young. The male calls to the nest much during the forenoon and some in the afternoon. The male began calling in the nest-box in the very early morning, before there was daylight. The male goes to the nest-box and calls. The female sat in the nest-box and called for straws. During the afternoon, and especially in the morning, the male spends considerable time in the nest calling for the female to come to the nest-box and renew the cycle.

THE NATURE OF THE NEST-CALL.

The nature of the nest-call is illustrated by the following excerpts taken from several different manuscripts:

When on the nest the male bronze-wing gives calls which are rather loud and strong—like a groan of a cat, a deep moaning sound. The male's call is stronger and a little longer than that of the female. His call is nearly a second long. The female's call has a vibration which I can not detect in that of the male; his call is a deep, full, moan-like sound. The male makes a distinct nod of the head with each call. The male gave two

¹ Much material on this topic is given in Chapter X.

calls, nodding his head strongly with each call as usual. This call sounds a little like the groan of a cat that is cornered and threatened with a stick—a groan, a growl of despair, as the animal seems to realize there is no escape and lies down and faces you. The female's call has a distinct vibration in it, and there is always a slight opening of the beak as it is made. The male's nest-call is 1 second long, and about 2 calls are given in 5 seconds; this was the usual rate, but it was sometimes slowed up to 2 in 6 to 7 seconds. The interval between calls was thus sometimes 3 seconds or longer. These calls were answered by the female from her cage, but her calls were not as loud and full as those of the male. The male went to his nest-box and began calling at the rate of about 12 times in 60 seconds. The male wags his wings slowly as he calls and also bows with each call. The wings are moved outward and upward and returned to the side of the body, sometimes 6 to 7 times in 5 seconds. There are usually 3 to 4 wags of the wings for each call; these are larger or smaller according to the earnestness of the bird and his call. If the female calls and walks forward and the male sees her trying to reach him, he becomes more animated in calls and movements of the wings. The nest-call of the bronze-wing is a single note, homologous with the nest-growl of common pigeons. It is a monotone and like a low groan; it is clear and hollow, like the sound from blowing in the mouth of an empty bottle. The male is on the floor calling at the rate of 9 times in 30 seconds; his calls appear to be a whole *second* in duration. In delivering, he bows his head so that the back of his head is about on a level with his beak, and his beak is turned vertically downward. The male is in the nest, and the female is on the floor; he is calling leisurely, at the rate of 17 times a minute. He usually bows with each call, although the female scarcely moves her head. The female called twice in answer and flew to the perch; the male then quickened his calls to about 3 in 5 seconds, each call being nearly a second in length.

The nest-call of the male *Geopelia humeralis* is the single note of the bronze-wing broken up into rapidly repeated short notes: it is a string of notes run off consecutively.

The call of the male *Ectopistes* is a succession of short notes, and sometimes a louder and more prolonged call, corresponding to the coo-call of doves. The female's call is less loud than that of the male; her call is a very crude one as compared with that of ring-doves. It is a rather hoarse, low sound, impossible to describe. It is a simple squawk, somewhat as if produced by a bird that has lost control of her organs of voice or that has never learned to use them. The male makes a similar call, but louder and more explosive. The male passenger flew back and forth, calling his mate *while on the wing*. This behavior was noted a second time.

The male white-faced pigeon (*Leucosarcia picata*) calls his young with the same call and at the same rate as he calls his mate; it is also the same call that he uses after his mate has laid an egg. He gives two calls a second, and, posting himself on a perch or a shelf, he keeps up this monotonous call by the hour. The calls are evenly run off, the bird holding himself in one position. The call is loud and clear, and sounds like a short whistle, the breath being expelled in a short forcible puff. I know of no other pigeon with such a voice. Still, one can say that it is the pigeon *oo, whistled twice each second*. The sound is not like *oo* vocalized, but whistled across the mouth of a bottle; *i.e.*, the lips are held as if to give the vocal *oo*, but the air is first put into vibration when expelled through the lips.

THE NEST-CALL OF THE MALE BRONZE-WING.

The nest-call of the male bronze-wing has then about the same *length* as the "perch call," but the latter is accompanied by a bowing of the head, which means that the effort is stronger than in the former, this position being one that conduces to rather deeper and stronger sound. I notice, however, that a slight nodding of the head does accompany the nest-call. The bowing done in connection with the nest-call is greater the louder the call, *i.e.*, when the male exerts himself most earnestly he strengthens his call with the

bowing. He may keep on with the calling for some time without any bowing movement. When the female comes to the nest he keeps on calling with his head held low, so that no bowing is required. The nest-call is accompanied, not by any appreciable bowing of the head, but by a slow and even up-and-down movement of the wings. This latter is a shoulder movement, the wings being lifted from the sides of the body and wagged up and down simultaneously; or, if in a shorter arc, they are moved out and in. If the female comes near the nest the action is quickened and the calls are more frequent; then, too, the head is held lower and the tail a little higher. The "wing-movements" are those of the *young* when appealing to the old birds for more food.

GROUND-CALL OF THE MALE BRONZE-WING.

In order to get records of the time occupied by the ground-call of the male bronze-wing I placed the two members of a pair in different rooms of my home. The male was placed in a rear room and the female was in a front room. The female answered the calls of the male. His calls were loud and strong and were given with a full neck and a slow bow. My various counts were as follows: 11 calls in 30 seconds; 21 calls in 60 seconds; 10 calls in 30 seconds; and 20 calls in 60 seconds. This gives about 3 seconds for a call, 1 second of which is the duration of the call and 2 seconds is the interval between calls.

NEST-CALL OF THE FEMALE BRONZE-WING.

The rate and duration of the nest-call of the female bronze-wing was recorded for two particular females. In the first case the female had been on the nest for an hour. She was then calling, and her consort was on the floor looking for straws. I found that she sometimes gives a single call at intervals of 5, 10, 15, or more seconds; and that she will then begin to call at shorter intervals, for example, two or three times in 5 seconds, 8 times in 16 seconds, 4 times in 8 seconds, then skipping over intervals of 5, 10, or more seconds. She repeats the call continuously, when the male goes to the nest, at the rate of about 7 times in 10 seconds. Each note is three-fourths of a second in length. It is a single note, a moderately prolonged monotone, with a little vibration in it that is sometimes quite noticeable.

In the second individual the call was a little less than a second in length. It was repeated frequently while the male was away hunting for straws. The call has a distinct vibration in this female, and it is often a little husky and jarring. The female calls at about the rate of 2 in 4 to 5 seconds or 3 in 7 seconds. Sometimes this goes on for half a minute without particular pause. Sometimes the interval between the calls is only a second, then a second and a fraction, varying from 1 to 2 seconds. The *interruptions* are from 5 to 30 or more seconds. Some series gave:

Rate.	Interruptions.	Rate.	Interruptions.
3 in 5 seconds...	15 seconds.	5 in 10 seconds...	30 seconds.
8 in 20 seconds...	5 seconds.	4 in 8 seconds...	10 seconds.
3 in 5 seconds...	5 seconds.	4 in 10 seconds...	9 seconds.
6 in 10 seconds...	8 seconds.	3 in 6 seconds...	10 seconds.
11 in 30 seconds...	10 seconds.	5 in 10 seconds...	8 seconds.
10 in 20 seconds...	20 seconds.	6 in 18 seconds...	9 seconds.
12 in 30 seconds...	10 seconds.	7 in 15 seconds...	5 seconds.
8 in 20 seconds...	12 seconds.		

NEST-CALL AND MATING INSTINCT IN THE YOUNG.

The young of a pair of bronze-wings had been removed to the adjoining half of the cage on the day a first egg was laid. Shortly afterward one of the young, presumably the male, went into his nest-box and began to call and to wave his wings slowly up and down, precisely like an adult male calling the female to the nest. The voice of the young is not

yet mature and is a little broken, but the call is delivered in the correct manner. At that time this young bird was only 9 weeks and 1 day old.

Another instance of the giving of the nest-call by a very immature bird was as follows: A young passenger-pigeon, only 59 days old, was standing on the perch in his pen in my library. I let a pair of ring-doves free in the room. These very tame doves flew about in delight. When they alighted in front of the pen containing the young passenger the latter promptly raised his tail and bowed his head, giving the call-note of the parent species perfectly. This occurred 5 weeks and 3 days after it had been taken from its parents, and since its parents had been kept in the back yard the young passenger certainly could not have made the note in imitation. When he was about 2 weeks old he must have heard his parents thus call in preparing for a second nest, but this was the last time the old birds gave the call, for they molted soon afterward and made no more calls for nesting. The young passenger repeated this call again on the following day. (R 28, R 33, R 29, SS 4, Sh 8/13.)

CHAPTER III.

THE PAIRING OF PIGEONS.

Pigeons normally pair with the opposite sex of their own species, and these matings are popularly supposed to represent a high degree of fidelity. Their fidelity is, however, by no means absolute, and they may mate with individuals of their own sex and with members of a different species. On occasion they may attempt to gratify the sexual passion by other means. Descriptive of such anomalous behavior, this chapter contains material bearing upon the question of species, sex, and individual recognition, and the basis of species and individual preferences.

INFLUENCE OF BEHAVIOR.

That birds of the same species usually mate together is a matter of the commonest observation. It is, however, a very interesting fact that among pigeons the sexes are not able to distinguish their opposites by sight. The male, for example, does not know what the female sex is; he will just as quickly mate with a male as with a female, provided the opportunity is given. But these birds have a way of finding out the sex of their associates. If, for example, two male ring-doves are put together and both are disposed to mate, they will begin to pull each other's ears or feathers; each will shake the other, and by and by, as this continues, one or the other will get a little angry. This display of temper is not proper behavior for the female sex; it will be resented by the other bird and a fight will result, in which one or the other eventually drives the other off. If a female is put with the male the latter behaves in precisely the same manner as before. He first gives her a few shakes and she becomes very submissive—the proper behavior for the female. When the female does not appear to resent or return the shakes, but walks away, the male follows her.

It is very instructive to watch this behavior between two birds of different species. As an example, let us take the situation presented by mating a common pigeon and a ring-dove. The common pigeon is very much the larger; and if we try to mate a male ring-dove with a female common pigeon the small male will approach this large female very cautiously. If she is disposed to mate with him she will retreat; that gives him courage, and he begins to coo. She dresses her feathers and struts and makes no resistance to the domineering behavior of the male, and the mating is soon completed. If the female is indifferent or averse to mating, she may give the male a peck if he comes too near, and that usually puts an end to his efforts to mate; he becomes frightened and does not pay her any further attentions. It is therefore necessary to know beforehand, if possible, whether the birds are disposed to mate. If the female common pigeon is disposed to mate before the birds are brought together the mating can be readily accomplished.

In another cross-mating a male hybrid ring-dove was paired with a California mourning-dove which was supposed to be a female. The hybrid was eager to attract the mourning-dove, but the latter showed not the slightest interest in him. No progress was made in 2 weeks, though the male hybrid persisted in courting. After 2 months they became entirely friendly with each other. I then thought the match was to be a success, but, to my surprise, a little later I saw the supposed female trying to mount the male. It was soon learned that this supposed female was a male. I then placed this same California mourning-dove with another male mourning-dove. The two began to coo face to face; each offered the beak and tried to mount the other. Soon they returned to striking each other, and otherwise making it evident that both were males.

These mourning-doves, then, like ring-doves, do not know the differences between the sexes until they meet and exchange salutations. The male's place is to coo and strut, while the female retreats, bowing and showing herself off if she happens to be disposed. If she does not retreat, the male tests her by pecking and claiming his mastership. The behavior is the only guide they have in selecting a mate of the right sex. This may seem incredible, but it is certain.¹ (SS 10, C 7/48.)

INFLUENCE OF VOICE.

Fulton, on page 38 of the work already cited, states in regard to the influence of voice:

"One more caution must be added in regard to mating the birds. It frequently happens that, on account of proved sterling qualities, it is desired to breed from an old pigeon as long as fertile eggs can be obtained from him; and this can only be done by matching him with a very young hen. Such a pair will frequently breed well; and we have had fine, strong young ones from an old barb over 10 years of age which had won many prizes. But it is in such cases particularly needful to avoid having in the same loft a lively young cock *with a strong voice*, for if this is the case the young hen will frequently leave her eggs to reach and pair with the young bird, even though he be already mated, and thus all the owner's plans are liable to be frustrated."

INFLUENCE OF SOCIAL ENVIRONMENT.

If a bird of one species is hatched and reared by a wholly different species, it is very apt when fully grown to prefer to mate with the species under which it has been reared. For example, a male passenger-pigeon that was reared by ring-doves and had remained with that species was ever ready, when fully grown, to mate with any ring-dove, but could never be induced to mate with one of his own species. I kept him away from ring-doves a whole season, in order to see what could be accomplished in the way of getting him mated finally with his own species, but he would never make any advances to the females, and whenever a ring-dove was seen or heard in the yard he was at once attentive.² (SS 10.)

It may be remarked by the editor that the discovery of this principle furnishes the key to Professor Whitman's success in hybridizing the various species of pigeons. A novel and important principle of behavior is here involved. The range of stimuli to which an instinctive tendency will respond may be modified by habits acquired long before the first expression of the instinct. The first expression of a delayed instinctive tendency may thus be in part a function of all that the organism has previously acquired.

PAIRING OF FEMALES.

That behavior is of prime importance in sex recognition is apparent from the fact that females sometimes pair with each other. It is not always easy to distinguish the sexes on the basis of any observation of morphological features. Such distinctions are best made in terms of behavior during the breeding cycle. For this reason it happened that, in his breeding experiments, the author occasionally

¹ Does a pigeon distinguish males from females in general, or does he know the female only in his own mate? The male pigeon usually knows the sex of each bird in the flock, and is always ready to play up to the females. When a new bird comes to the flock he does not seem to be so sure of its sex at first; but he tests it by display behavior. If the newcomer proves to be a male, he then pays less attention to it. It is wonderful how quickly one pigeon can tell whether he is looked upon with favor and liking by another. It seems as if the expression of the eye tells at once that the bird likes or does not.

I have noticed that some males are less successful than others in securing mates. Of two given males it will generally be observed that different females prefer the same one. And this is usually the more active male. An exceptionally strong male may even entice a female away from her mate, especially if he defeats her mate in fight. The female is more inclined to thus desert her former mate for a victorious male at the time the female is ready to start a mating cycle than at other times. At any other time she would pay no attention to the strange male. (Conv. 7/2/10/ W.C.)

² Illustrative material may be found in Chapter X.

mated two birds on the supposition that they were male and female, and the mistake was not discovered until the latter part of a reproductive cycle. Sometimes more or less spontaneous mating of females may occur. "Two females, one an ordinary domestic dove and the other an impure fantail, settled in a cot and both laid in one nest and exchanged with each other as if male and female."

It is probable that females *W1* and *W2*, for which complete records are given in Chapter VII, constitute another case in point. These two female white rings (*St. alba*) had been purchased in November, 1895, and had been mated on the supposition that they were male and female. The record shows that they had long been together. *W2* laid two eggs before being mated with the male *X*. *W1* laid her first egg two days after being mated with *X*, but he did not respond at once and it was noted in the record that there were probably no unions and it is unlikely that the egg had any chance of being fertilized. Since the two females laid at practically the same time (one day apart), it is very probable that they had united and stimulated each other to the production of eggs.

An extended account of the behavior of two pairs of female blond ring-doves (pair *D*, and pair *E*) will be given. These two matings present most of the phenomena that are to be met with in such matings of female with female. To aid the reader in grasping the intricacies of the detailed account of "pair *D*," the following brief synopsis of events is appended by the editor:

A first egg was laid during the afternoon of January 24, though the act was not observed. No account of the previous mating activities is given. The second egg was laid at 9 a. m. on the 26th, and this act was observed and described. At this time and during the rest of the day the alleged male persistently tried to take the nest and perform his regular incubation duties. On the next day he failed to exhibit normal masculine behavior, *i.e.*, he did not incubate the eggs during the day and sit on the perch at night; he did, however, behave normally thereafter until February 8, a period of 11 days. On the 8th and 9th his behavior was regular, with the single exception that he tried to obtain the nest late in the evening, when he should have been on the perch for the night. A second set of eggs was laid February 27 and 29, and this bird did not begin to exhibit masculine incubation behavior until March 3, when he attempted to assume incubation duties late in the afternoon. On the 5th this alleged male was discovered *laying an egg* at 10 a. m.; and 4 eggs were found in the nest, so that the third egg was probably laid on the afternoon of the 3d, when he attempted to take the nest from the female. The account is given as it was written—the bird which was thought to be a male is referred to as a male.¹

For some time before this egg was laid on Jan. 26 the male of "pair *D*" kept getting into the nest-box² and trying to get possession of the nest. After driving him away several times and finding that he was determined to continue his efforts, I gave him a

¹ The two birds of this pair hatched together in the same nest—were full sisters—as is shown by reference to table 174, Volume II. It is there noted that the "second egg of the clutch was smaller than the first"; this is a reversal of the more usual size-relations of the eggs. In view of later work on sex it seems not improbable that the "supposed male" described here was hatched from an egg which was less definitely "female" than was the more feminine mate.—O. R.

² This nest-box was about 8 inches long, 6 inches wide, and 5 inches deep.

cuff that frightened him and put a stop to his returning to the nest. He then went to an empty box on the other side of the cage and settled down as if he were over the eggs. After an hour or so the female came off the nest, and I then had to go and drive him out of his empty box. He flew over to the nest, but remembered his cuff and seemed to anticipate another. I stepped back so as to relieve him from any anxiety, and was surprised to see him deliberately forsake his nest and eggs and walk back to the empty box, into which he at once jumped and then settled down as if performing his duty. I drove him out several times with the same result. I then put the female back and she at once went on the nest. The male, again dislodged from his box, went to the nest and fairly induced the female to leave. He remained only a few moments after she left and then walked back to sit in his empty box. Again I placed the female back and left her there and the male in his box. During most of the afternoon I was away and could not observe what occurred. On returning at 6 p. m. I found the female on the nest and the male sitting on the edge of the box immediately over her. This seemed again unaccountable, for in the parental pair the male never sat near the nest. To sit right over the mate, without regard to consequences, was a departure from usual neatness and good breeding that surprised me. I carefully removed him to a perch, where he at length remained.

Why did this male behave thus in regard to sitting? Evidently he felt the impulse to sit in the morning at the usual time. But it happened that the second egg was about to be laid and the female would not leave. He followed his impulse, and when I taught him by rough usage that he could not sit on the nest just then, he sought to satisfy his wish by sitting in an empty box. Having sat an hour or so there, he became accustomed to the place, and persisted in leaving the eggs before his eyes and going back to sit on nothing but the dry dung with which the box was partly filled. For a male dove that had never before seen an egg, or had any experience in nesting, this strong desire to sit—and to sit on nothing rather than not at all—is very remarkable. It would seem that the whole organization is ready to sit. The male and female advance from one stage to another together; they mate, and the actions of the male stimulate the female to the production of eggs, and her actions carry him along, so that at the proper time both take part in finding a nesting-place and in building the nest. They coöperate in building the nest, and when the eggs are laid the male is all prepared to perform his new duties and to renounce, for a time, his sexual pleasures.

At the end of the period of incubation (two weeks), and a week or more in care of the young, the pair renew the cycle of events. The young are fed by both parents until the female is about ready to lay again, then the male continues the work alone and the young begin to help themselves. As soon as the time of hatching arrives, the previous young begin to learn that they are no longer wanted, and if they do not leave the male takes them in hand and drives them without mercy. All this is to the end that the new comers may be safe in their nest from attacks by their elder brother and sister when the parents are away. The bird has no idea of what its actions mean, for its actions are according to *feelings*, which follow each other in regular *serial* order, making the same round each time.

On Jan. 28, the second day of sitting, the male began his duties by again returning to the empty box; this was done a few moments after the female came off the eggs. I then covered the box so that the male could not get into it, and left him to see what he would do. He went to the box and tried every way to get into it; failing, he went to the nest and sat a moment, but was not satisfied, and soon returned to his box, flying over it and around it in vain endeavors to get into it. He seemed desperate in his efforts. Again he returned to the nest, but did not stop to sit down, but got up on the edge of the box and dressed his feathers a few moments, quite free from any fear; he then again tried to enter his empty box. Seeing that it was hopeless to try to get him to cover the eggs in the nest, I filled a pasteboard box—just large enough to fit in the empty box—with hay, put the

eggs into it, and placed all inside the empty box. The male went at once to the eggs, but remained only a few moments, and then came down to his mate.

I then tried the female to see if she would accept the eggs in the new place. She looked at the eggs with an inquisitive air, but decided to leave them. I then returned the eggs to the first nest and there she at once covered them. But very soon the male came to her and got into the box beside her; this she took as an invitation to leave, which she did. But the male, as before, stopped only a moment, then went to his box and began to work at forming a nest in the hay which I had left there. I then again returned the female to the nest. She was unwilling to enter the box, but I placed her inside and held my hand so as to prevent her getting out. She moved about carefully, noticing the eggs, and finally decided to cover them. The male went on working at his nest. At 8^h 50^m the female left the eggs, and at 8^h 55^m I transferred the eggs to the nest of the male, placing them under him. He drew back a little from my hand but did not leave the nest. Soon after I left him, however, he came off and flew down to the floor of the cage with his mate. At 9^h 05^m I placed the female back on the nest and gave her the eggs; the male went to his nest again, and continued to fashion his nest. At 9^h 10^m I placed one egg under him, leaving one with the female. Both remained quiet, the male working to complete the shaping of his nest, turning round now and then, and placing now this straw, now that. At 9^h 15^m the male left his box and went to the female's. She resigned, but he did not stop but went back to his own nest. I then gave both eggs to the female in her own nest, which she again accepted. At 9^h 30^m I again gave both eggs to the male, taking the female off her nest. But he soon left them. I next transferred the paper box containing the eggs from the box of the male to that of the female, and she accepted the new box and nest here, although a moment before she had refused them in the box of the male. This shows how strongly the "place" of the nest acts on these doves.

The male soon returned, claiming the box, nest, and eggs. The female retired and the male remained a few moments, then (9^h 45^m) went to his empty box; but he now missed the straw and did not feel as if things were right. Still he persevered, and entering the empty box he began to call vigorously for his mate, as if inviting her to make a new nest. This was the first time that he had so called, and it may be taken as an indication that he is forgetting his business of sitting and thinking of a new nest. At 10^h 15^m he is still calling. I give him some strands of hay, which he uses. At 10^h 30^m he flies over to the female, and she retires at 10^h 34^m. The male remains 5 minutes, then goes back to his box, and then to the floor to eat. At 10^h 45^m the male returned to the female's nest, but did not really settle down to cover the eggs, and soon left for his box. I then covered his box so he could not get inside. He then went back and the female again retired (10^h 49^m); he stopped only a moment, then went to his own box and began to call, although he could not enter, and had only a naked flat surface to stand on. Soon after (10^h 52^m) the female went back to the eggs of her own accord. I was then absent until 11^h 35^m, at which time I found the male beside the female on the nest; she retired, leaving him in possession; but he almost immediately flew down to the floor of the cage with the female, picked up a straw and went back, did not stop to sit, but returned to the floor just as the female picked up a straw. She carried this to the nest and then took her place on the eggs; again she was visited by the male and retired as before.

The male was on the nest at 11^h 43^m but again deserted at 11^h 45^m. The female carried another straw at 11^h 47^m and took her place. The male returned at 11^h 48^m and the female retired and brought straws. The male goes off at 11^h 50^m, prompted by the presence of other doves near his box. The female notices that he is off, and goes back, but has not time to take her place before the male returns; she again retires, but he flies back again to his box (11^h 58^m) to drive off the other doves which are in a box close to his and separated only by a wire netting. I then put up a screen so that he could not see the doves in the

neighboring box. But he did not sit properly, moved about, and flew off at 12 o'clock. A moment later the female returned of her own accord, but was immediately followed by the male, and she again retired without entering the nest. The male entered and beckoned with his wings and by calls for the female. At 12^h 15^m the male left the nest again, went to his box, and called the female. She went back to her nest, only to be followed by the male and again to retire, leaving him at the nest. This happened several times between 12^h 15^m and 12^h 30^m. The male went off at 12^h 35^m, went to his own box, and called the female. She returned to the nest of her own accord at 12^h 46^m, while the male was still calling on his box. Between 1 and 1^h 50^m I was away. At 1^h 50^m both birds were on the floor, but the female went at once to her nest and was followed by the male. She left the nest and he went off to his box, calling her as usual. A moment later she went to the nest and at 1^h 55^m he returned; she promptly left the nest to him. At 2 the male abandoned the nest and she returned to it. At 2^h 10^m she left for a moment and then returned while he remained on the floor. At 2^h 12^m the male carried a straw and took the nest from her again. At 2^h 13^m he flew to his box and she returned of her own accord; the male in the meantime was calling. At 3 she came off and both were on the floor; she at once went to the nest. I was absent from 3 to 6 p. m. At 6 p. m. the male was sitting on the edge of the box over the female. I placed him on his perch beside the box and he remained.

At 8^h 30^m a. m. on Jan. 29, the third day of sitting, the male took his place on the nest and remained there quite contentedly. He behaved normally in every way but came off at 9 o'clock and remained for 15 minutes, both doves then spending the time together on the floor of the cage. At 9^h 15^m he returned to the nest; he came off for a few moments at 10^h 50^m and then went back. He now seems to be in a normal mood. The male has behaved properly all day, except for his long stay away from the eggs in the morning. When night came he did not perch over his mate, but took a place at the opposite side of the cage. Thus *regularity* in behavior sets all points right; in other words, normal conduct in one particular is correlated with normal conduct in other respects.

On Jan. 30 the male was found on the nest at 7^h 30^m a. m. He came off at 7^h 45^m and the female went on. He returned with a straw at 7^h 50^m and she resigned her place to him. All went normally for nine days thereafter, or until the night of Feb. 8, just before the day on which the young would begin to hatch. The male went to the nest and tried very hard to crowd out the female and obtain possession. Having failed in one attempt, he left the nest for a few moments, but again returned and struggled to work his way in. Again he failed to get possession and soon retired to his perch, as it was fast getting dark; but he tried yet a third time before giving it up. On the next night he again behaved in the same way.¹

The second set of eggs was laid on Feb. 27 and 29. The male took his place on the nest beside the female for the first time on the evening of Mar. 3, having kept the perch regularly up to that time. He left the nest, however, at 8^h 40^m p. m. of this date and took the perch. Probably my going to the nest stimulated him to retire; at any rate, he did so just after I had left the nest.

On Mar. 5, at 10^h 05^m a. m., I found the supposed male laying an egg; and, just after the egg was dropped, the bird stood up so that I could see under her, and I was astonished to find 4 eggs. The second pair of eggs were not measured, but they were fully as large as the first. *It is now clear that "pair D" represents two females*, and this explains the fact that the two birds have behaved towards each other now as male, and again as female. I could not understand this before. It explains further why the supposed male has never done much crowing.

¹ Since this pair, as determined later, consists of two females, the eggs necessarily did not hatch. The failure to hatch, however, would arouse no suspicion as to the state of affairs. Incubation was imperfect during the first stages, and failures under these circumstances are not uncommon.—EDITOR.

The second pair of blond ring females was known as "pair E" and their behavior was described as follows: This pair of blond rings has behaved in a remarkable way in preparation for egg-laying. On Feb. 2 the female began to remain over-night on the nest. I expected she would lay, but she kept on sitting on the nest for four nights and for much of each day. Her wings did not droop at any time as they usually do when eggs are about to be laid.

A very remarkable change was made on Feb. 8, for the male took the nest for the night and the female took the perch perfectly contented. The male remained on the nest as if to the manner born. It is certainly very strange, this sitting on an empty nest so long, and then the male usurping the functions of the female in night-work.

On the following morning the male came off the nest quite early, at about 7 o'clock or a little before, and the female went on soon after. At 8^h 30^m I found the male on the nest again, and apparently acting just as if he was in charge of the eggs. At 9^h 10^m he came off, and the female went on soon after. They thus continued to exchange with each other during the day. At night, at about 5 o'clock, I saw the male go to the nest, and saw the female retire to her perch without making any objection. They continued this, he sitting at night, and both during the day. On the night of Feb. 12, *both* sat on the nest during the early evening, but the female took her place on the perch at 8^h 45^m. Both sat on the nest during the nights of the 14th, 15th, and 16th.

On Feb. 23, these birds were still sitting on the empty nest, regularly exchanging during the day and both sitting at night. But I now notice that both are at times less devoted to the nest, *i.e.*, they come off occasionally to eat, and do not hasten back with the usual anxiety; still, I have not noticed any long stay away from the nest. The same conduct occurred on the two following days.

During the night of Feb. 25 and 26, *both birds sat on the nest as usual, but both came off in the morning, and remained off*. They have bestowed the usual attentions on each other preparatory to nesting. They have shown some desire to fly from the cage, but have not shown any long-continued restlessness. They have now evidently finished up the course of sitting without ever having produced an egg, paying the same constant attention to an empty nest that they would have given to eggs. Evidently the instinct to sit does not depend upon the presence or production of eggs, but runs its course and comes to an end without any stimulus from without. The sexual passion rises and the work of making a new nest begins. The period of incubation, if we can so call it, may be said to have begun on Feb. 8, and to have continued until this date (Feb. 26) or 2 weeks and 4 days. But I am mistaken in thinking the nest to be fully abandoned. I now find both birds on the nest at night as usual.

On Feb. 27 both are off the nest and very restless, trying to get out of the cage. At night I find both have left the nest and gone to the opposite side of the cage to perch in the old place where they used to roost before making a nest. We can now be sure that the nest is finally abandoned and will not be occupied again unless for a second round of incubation. The period of incubation would thus be 2 weeks and 5 days in this case, the last day being a broken and desultory one.

On Feb. 28 these birds were very restless in the morning; both tried to get out of the cage and were evidently intent on finding a place for the nest. On the next day they devoted some time to a box opposite to the old nest which contained no straw. On the day following I covered the box so that they could not get into it. They tried it, and failing, were extremely restless and desirous of getting out of the cage. They stood before the door and kept flying up as if wishing to have the door opened.

After trying first the covered box, and then to get into my room, this pair went, on Mar. 3, to the old nest and soon settled down there as a last resort. It is remarkable how strong the instinct is to *place the new nest in a new locality*. The white rings (*St. alba*)

showed no such instinct, in at least one instance, though they might have done so had they not been ready to lay immediately, *i.e.*, without any interruption in incubation.

On March 5, between 3 and 5 p. m., one of these doves laid an egg. *The supposed male had possession of it* when found, and the other (supposed female) sat on the nest close beside. Is the supposed male a female? And have we thus another pair of females, *mating, nesting, copulating, and incubating*, as if male and female? The two doves are devoted to each other, and their behavior is that of male and female. The supposed male acts as a male, except that he crows very little and does not have the full sonorous voice of the known males. Which dove laid the egg I am as yet unable to say. On Mar. 7, a second egg was laid at 7^h 10^m a. m. *Both doves are females.* Their age at the time of the second egg was 6 months and 20 days. (R 19, C 7/17.)

In continuing Professor Whitman's work, Dr. Riddle has studied with some detail this pairing phenomenon between two females and has given the following summary account of his observations:

The continued isolation of two female doves is usually sufficient to induce their mating with each other. Many of the phenomena of a normal pairing will be exhibited by such unnatural pairs. Copulation, nest-building, egg-laying, incubation, and feeding of young, all follow in the usual order. In working with hybrids between *T. orientalis* and *St. alba*—sex-controlled material produced by Professor Whitman—I have been able to carry considerably further the analysis of this conduct, obtaining the following significant results:

(1) One or both members of a pair of females may function as the male in copulation, and one may so function much more frequently than the other.

(2) The amount of this predominance in mounting is dependent upon the *relative masculinity* of the females of the pair.

(3) A bird predominantly masculine in one mating will show predominantly feminine behavior in another mating with an exceedingly masculine female.

(4) This relative masculinity rests upon a physical and physiological basis imposed upon these birds by the conditions which affect their own sex-determination.

The several features involved in the sex-control are treated elsewhere (see Volume II of these works). A complete account, by the present writer, of the relative masculinity and femininity of female and male birds respectively will appear in a volume now in course of preparation.

In our more recent studies of the detailed behavior of the members of pairs of the same sex, some data have accumulated which touch the question of the relation which "energy" and "aggressiveness" bear to sex.

In the main, Professor Whitman's conclusion that the male is the more energetic and aggressive finds confirmation here; furthermore, the more "aggressive" females studied in the new lines of work have proved, in most cases, to be the more masculine in their sex behavior; *i.e.*, they have more often taken the part of the male in copulation. There seem, however, to be some instances where this simple rule does not hold. Certainly there are cases where the "larger" bird is not the more masculine; likewise, more "eager" birds which are not more masculine. The exceptions to the above rule, though possibly of importance, can be treated adequately only in connection with our own forthcoming work.

One may ask, How completely will the more masculine of a pair of females assume the duties and behavior of a male? In reply it can be said, first of all, that *both try to be females*; and that it is chiefly where two simultaneous feminine behaviors are precluded by the nature of the activity, as in billing or copulating, that the testing struggle comes.

If two such females differentiate themselves in the matter of "display" I have not noted it; though I have not definitely, consistently, or preparedly looked for it. The more

masculine female has more often been the "jealous" driving one. I have failed to note different rôles taken in "nest-building."

In sexual "billing" the more masculine bird usually, but not invariably, receives the bill of her consort. Sometimes, however, in the rather tense sharp contest on this much-indulged detail, the more feminine female is induced or forced to yield her open mouth; in which event she is more often induced to follow this by mounting than when the billing contest terminates differently. She may, however, play the part of the male in the "billing" and yet function as a female in the succeeding copulation. In general, the one that usually "bills" as a male also "jumps over" and mounts, as a male. Important here too is our finding that such a masculine member of the pair is usually *a day or more behind her mate in egg-laying, and may not lay at all!*

It is evident, therefore, that those females which mount as males much more than do their consorts are rather *consistently masculine* towards these consorts. But, as stated above, where quite free and unopposed their activities are those of females. This fact must not be disregarded. Whether a pair of females maintain this sort of differentiation during the incubation period is a matter not yet tested; in fact, this may not prove easy to decide since most female doves seem willing to go to the nest by day whenever the eggs are left uncovered; and both, or either, will sometimes sit at night in cases where both have laid eggs. This matter certainly needs further investigation.

PAIRING OF MALES.

Males have also been known to mate. Two of my male passenger-pigeons mated with each other, notwithstanding they were in a pen where there were several unmated females desirous of mating. (C 7/48.)

Dr. Riddle has noted the same phenomenon and has furnished the following account of the behavior:

The mating of male with male has been seen to occur among certain doves. That is to say, two males may pair, cease to drive or fight each other, mutually defend a nest, and either or both actively, and with apparent completeness, take the part of a female in copulation. Thus mated they may go through the whole of the breeding cycle of copulation, nest-building, feeding, and rearing of foster young. The few cases of such matings that I have thus far observed present, however, widely varying degrees of completeness of the mating. Only a single pair of (young) blond ring-doves has been seen to carry out the entire program stated above.

The male birds thus far known actively to take the part of a female in the sexual act are blond rings (*St. risoria*), white rings (*St. alba*), and hybrids between the Japanese turtle-dove (*T. orientalis*) and the white rings. Among these forms matings are more easily secured if *young* males are used. The latter statement can now be made confidently, though the first mating observed was between two *orientalis-alba* hybrids whose age was 4 or 5 years. The fact that one of these birds seemed actively to function as a female, in a copulation which I chanced to see, led me to make several matings with a view to a study of this situation. I had already learned that the sisters of these same hybrids, of all ages, can be made to mate with each other under certain conditions. A number of pairs of mature males were isolated; some of these were observed for several months, but no real matings resulted from any of these cases. Even the pair of birds which was first seen to copulate, in a pen where there were only male birds, fought and drove each other when isolated from the group. Between these two birds very few matings were later observed which could give any reason to believe that one was really and actively functioning as a female; both birds of course occasionally attempted the part of the male in copulation, but to the end fierce fighting was the rule of the day in this cage as it was in the others.

Early in 1913, however, two young (4 to 8 months) ring-doves were obtained from a dealer who thought them to be a male and a female. These birds, kept apart from other doves, mated with each other within a month and proved to be two males. One of these males during a whole season frequently and actively functioned as a female, though more often attempting to copulate as male. It is doubtful, however, whether the *other* blond ring ever *actively* functioned as a female in a complete copulation; usually he flew, or slipped, from the perch soon after the mate mounted him. This pair incubated eggs and reared young.

Other pairings were obtained between young *orientalis-alba* hybrids, but in both successful cases the birds soon passed into a fighting, driving stage. In one of these cases either male would sometimes actively function as a female. Two other pairs were obtained, the first consisting of a pure white ring male and a pure blond ring male; both were very young. Both birds were seen actively to take the part of females. The second pair was formed by the union of two very young birds. One was a white ring and the other was an *orientalis-alba* hybrid. This mating has now been continued for more than 3 months.

The following data concern the incubation behavior of two male blond ring-doves. These birds have now incubated and reared two nests of young. In incubating the first lot it was not noted whether the more masculine or the more feminine of the pair nested mostly at night; it is known only that the more feminine one was on the nest during two nights of the incubation period. During the incubation of the second lot, however, more complete records were made. Here the more masculine male was on the nest during 9 nights and the more feminine male nested during 5 nights. For 2 nights there was no record. In considering these data it is probably well to note that the more masculine of this pair was nearest ready to incubate when eggs were given, and that the unnaturally functioning male was late in getting ready (third night) for incubation; an unnaturally functioning female is similarly delayed one or more days in the delivery of her eggs.

The difference in masculinity of these two birds lies not so much in any difference in their willingness to mount as in the fact that the one has almost uniformly refused to take the part of the female in a completed copulation, whereas the other has readily done so. This latter bird also has a wider space between the pubic bones and so was at first taken, by a dealer and by myself, for a female.

PROMISCUOUS TENDENCIES.

The author has noted the phenomenon of "stolen matings" in numerous breeding records, but without any discussion of it. Examples may be found in manuscripts BB 9, G 19, and G 20. Naturally these matings will be found only among those birds which were allowed their freedom, *i.e.*, the common or domestic pigeons. The female of a pair, during the mating period, will accept matings from other males as well as from her own mate. These illicit copulations on the part of a *paired* female were observed, but no statement was made as to whether the offending male was free or paired. Probably this promiscuous tendency characterized the male also. In one manuscript (C 7/7) we find the case of a male mourning-dove who regarded the author as his mate. This bird was twice confined with white ring females and refused to pair with them, although both were very eager to do so. This male, however, did not exhibit any hesitation in gratifying his sexual impulses at every opportunity. The important fact to be noted is that though *fidelity* is the rule, yet exceptions do occur; some tendency to *promiscuity* does exist. It is impossible to state whether this promiscuous tendency is

universal or limited to the domestic varieties.¹ In this connection one might suggest the possibility that the promiscuous tendency is somewhat universal and deep-seated, while the marked degree of fidelity characteristic of pigeons is a product of their division of labor in nest-building, incubation, and feeding of young. This division of labor of necessity keeps the two birds together and somewhat isolated from others of their kind and thus reduces the opportunities for illicit matings. In other words, pigeons might be promiscuous like fowls if, like these, the males were so constituted as to take no share in mating activities other than copulation.

Fulton, in his work previously cited, states:

"For although pigeons as a rule pair with great fidelity, exceptions are by no means rare; and cases have been known in which a cock has mated with two hens, and even assisted both in hatching and rearing their young; while we once possessed a cock which, though he never aided them in family duties, regularly paired with no less than *five* hens. This case being so very remarkable we took particular notice of it, and can vouch for the truth of what we state. To the naturalist such instances are particularly interesting, as showing that, under some instances, pigeons might possibly become gregarious, like poultry."

UNUSUAL PROCLIVITIES.

The old bronze-wing birds were beginning to prepare for a nest, the male taking the lead in going to the nest-box and calling. The male gradually became more earnest and more attentive towards the female. Not satisfied with her coolness, the male frequently mounted the *young* of the previous cycle (these young birds were 7 to 8 weeks old at the time).

The male bronze-wing was again anxious to copulate and renew the cycle, while the female was still taking care of the young. In response to the call of the female on the nest, the male raised his feathers a little and let his wings hang loosely at his side; he then wheeled about and gave a jump onto the corner of the seed-pan, stood there a moment, dropped his abdominal feathers, and fixed those about the anal opening as they are placed preparatory to sexual union. He turned again without going further and hopped off. Three times in succession he repeated this performance. The female's call set him off. I have seen him behave in this way two or three times before during the last few days. There was another call from the female and similar behavior over the corner of the seed-dish resulted. Before mounting, the male lowers his head and acts as if pressing down on the dish just as he does with his mate; then he gives a quick jump—both feet at once—halts on the edge, fixes his feathers, dismounts, quickly remounts, etc. When the female came down to the seed-dish the male attempted to mount her.

I once had a mourning-dove which I kept in my room during the winter. He became well acquainted with me and was quite tame. There were some other mourning-doves in the room and I expected that he would of course pick out one of them and mate. But when the mating season came, in March, he began to show an interest in *me*! Every time I came into the room he would jump into the nest-box, raise his tail and spread it somewhat, put his head down low, and begin to give the nest-call, looking at me and vibrating his wings very slowly as if inviting me to come. If I approached the nest he would be still more active and seem very much delighted. His little eyes would twinkle and he would turn around and look at me in the most loving and inviting way. He kept on in this way for a week or two and I finally had to break him of it by simply keeping out of his sight. At the time he was very anxious to mate and finally accepted one of his own kind.

¹ Dr. Riddle reports an instance of a hybrid blond-white ring-dove male being paired simultaneously with two females, one a white-blond hybrid the other a Senegal turtle-dove.

A fuller account of the history and mating proclivities of this same male, which was probably partly raised "by hand," is found in the following: A male mourning-dove (*Zen. 3*) was obtained when a few months old. He was mated $2\frac{1}{2}$ months later (Dec. 20, 1896) with a white ring-dove (*W1*). The male regarded *me* as his mate and drove other doves away from his nest-box. I had to cease going to his call in order to turn his attention away from me to *W1*, who was eager to mate and tried all possible ways to ingratiate herself in his favor. On Jan. 5, 1897, this male is still as fond as ever of me, and often tries to call me to the nest-box; if I go to him he looks happy and delighted and frequently drives his mate out of the nest if she answers to his calls. On Jan. 20 he flew to the nest-box and began calling me. Whenever I go near him he struts around and appears to welcome me as a mate, for he usually goes to the nest-box and drives his white mate off if she intrudes. On Jan. 27 this male still flies to the nest-box when he sees me come into the room, and he often calls me long and persistently. I now keep away from him. On Feb. 10, he still flies to the nest-box every time I enter the room; he then sits on the nest-box calling me. On Mar. 7, he still drives his would-be mate if she approaches him when I am near; he drives her and calls to me. This mourning-dove, on Apr. 7, still continues to call me, although I no longer answer him. He was finally mated with another bird. (R 33, C 7/7, SS 10.)

A SPECIAL CASE—NOT ABERRANT MENTALITY.

This story, which is taken from the *Mental Evolution of Animals* (p. 173) by Mr. Romanes, has been thought worthy of translation into German by Karl Gross in his *Spiele der Thiere*. The case was reported to Mr. Romanes by a lady, and is given in her own words:

"A white fantail pigeon lived with his family in a pigeon-house in our stable-yard. He and his wife had been brought originally from Sussex, and had lived, respected and admired, to see their children of the third generation, when he suddenly became the victim of the infatuation I am about to describe.

"No eccentricity whatever was remarked in his conduct until one day I chanced to pick up somewhere in the garden a ginger-beer bottle of the ordinary brownstone description. I flung it into the yard, where it fell immediately below the pigeon-house. That instant down flew *pater familias* and to my no small astonishment commenced a series of genuflections, evidently doing homage to the bottle. He strutted round and round it, bowing and scraping and cooing, and performing the most ludicrous antics I ever beheld on the part of an enamoured pigeon. Nor did he cease these performances until we removed the bottle; and, which proved that this singular aberration of instinct had become a fixed delusion, whenever the bottle was thrown or placed in the yard—no matter whether it lay horizontally or was placed upright—the same ridiculous scene was enacted; at that moment the pigeon came flying down with quite as great alacrity as when his peas were thrown out for his dinner, to continue his antics as long as the bottle remained there. Sometimes this would go on for hours, the other members of his family treating his movements with the most contemptuous indifference and taking no notice whatever of the bottle. At last it became the regular amusement with which we entertained our visitors to see this erratic pigeon making love to the interesting object of his affections, and it was an entertainment which never failed, throughout that summer at least. Before next summer came around, he was no more."

Mr. Romanes remarks:

"It is thus evident that the pigeon was affected with some strong and persistent *monomania* with regard to this particular object. Although it is well known that insanity is not an uncommon thing among animals, this is the only case I have met with of a conspicuous derangement of the instinctive as distinguished from the rational faculties—unless we so regard the exhibitions of erotomania, infanticide, mania, etc., which occur in animals perhaps more frequently than they do in man."

This pigeon, whose behavior has given it so wide fame as a case of deranged instinct, was undoubtedly a perfectly normal bird; and had Mr. Romanes been familiar with the antics of male pigeons, he would have found nothing in the performances to indicate

insanity. I have seen a white fantail play in the same way to his shadow on the floor, and when his shadow fell on a crust of bread he at once adopted the bread as the object of his affection, and went through all the performances described by the lady, even to repeating the behavior for several days afterward when I placed the same piece of bread on the floor of his pen. If one is looking for insanity in pigeons, let him first know the normal range of sanity and pay little heed to stories of inexperienced observers who are apt to overlook circumstances essential to a correct understanding of what they report.

It is not improbable that the lady's amusing pigeon at first took the bottle for a living intruder upon his ground and flew down to it for the purpose of driving it off. Finding it at rest, if his shadow fell upon it, or if his image was even faintly reflected from its surface, he would readily mistake it for a female pigeon, and after once getting this idea and performing before it, the bottle would be remembered and the same emotions excited the next time it was presented. The only value this suggestion can have is that it is based on a similar case. The lady's observations were not complete at the critical moment, *i. e.*, at the time of the *first* performance, and it is too late to mend the failure.¹

¹ Whitman, Myths in Animal Psychology, *Monist*, 1899, pp. 528-530.

CHAPTER IV.

THE INCUBATION PERIOD.

By the incubation period we refer to that part of the reproductive cycle which extends from the appearance of the first egg until hatching is completed. Some species may begin to sit on the nest before the appearance of the eggs, while in other cases incubation may be delayed until the advent of the second egg. Incubation, in a sense, exists for a week or so after hatching, as the young are at first covered almost as carefully as were the eggs. Our use of the term, however, may be justified as a means of classifying and describing the various activities of the reproductive cycle. The present chapter is concerned primarily with various statistical data rather than with behavior proper.

LENGTH OF THE PERIOD.

The time of incubation varies considerably in the different species. The shortest incubation period that I have known anything about is that of the wild passenger-pigeon, which is only $12\frac{1}{2}$ days; while that of the common pigeon is 17 to 19 days, and that of the ring-doves or turtle-doves is 14 to 16 days. (SS 10.)

T. H. Newman (Avic. Mag., May, 1908, 217-218) gives the incubation period of *T. pictaturus* (Madagascar turtle-dove) as 12 days (reckoned from the date of the second egg). I find these birds have a longer period, and furthermore, it is incorrect to start the period with the second egg, as development begins in the passage through the uterus before the egg is laid. (R18.)

Fulton (*op. cit.*, p. 39) says:

"The period of sitting among (fancy) pigeons is 18 days, reckoned from the day on which the second egg is laid, for one day intervenes between the first and second egg being produced. Sometimes, if the parent birds sit very close, the young are hatched on the seventeenth day in summer weather; not infrequently, however, the period of hatching is delayed to the nineteenth or twentieth day."

Table 3 has been compiled from the records. Besides differences of species it is to be noted that the period for the second egg is generally shorter than that for the first egg. This fact is probably a result, in part, of the irregularity of early incubation. Until the arrival of the second egg, incubation is intermittent and sometimes lacking (see subsequent topic "Early Incubation," Chapter V). This shortening of the time for the second egg secures a greater equality of the two birds in feeding. This fact is important in that the stronger and better-developed young is likely to monopolize the attention of the parents in feeding (see topic "Feeding of Young," Chapter VI). There is some slight indication in the table that the period tends to decrease with the advance of summer.

In this table we have given the data for the pure species¹ only, not hybrids. When two species with different incubation periods are crossed, the resultant period approaches a mean, with the female exercising a preponderant influence. Given two species *A* and *B*, with incubation periods of 12 and 19 days respectively,

¹ Domestic pigeons and the ring-doves are, however, included.

BEHAVIOR OF PIGEONS.

TABLE 3.—The length of the incubation period.

Species.	First egg.		Second egg.	
	Date.	Time.	Date.	Time.
		days. hours.		days. hours.
<i>Zenaidura</i>	5/11/97	14 22	5/13/97	15 0 ca.
".....	6/11/97	14 20 ca.	6/12/97	14 2 ca.
".....	7/29/97	14 21 ca.	7/30/97	14 0
".....	9/ 2/97	14 12-13	9/ 3/97	14 2 to 4
".....	5/ 8/98	15 12 ca.	.....	.....
".....	6/18/98	15 12 ca.	6/19/98	14 20 to 23
".....	7/18/98	14 12 ca.	7/19/98	14 0 ca.
".....	8/15/98	15 12 ca.	8/16/98	14 12 ca.
".....	6/13/99	15 12 ca.	.....	.....
".....	8/13/99	15 ca.	8/14/99	14 0 ca.
".....	5/18/00	15 12 to 14	5/19/00	14 20 ca.
".....	6/26/00	15 12 ca.	6/26/00	14 few hours.
Fantails.....	9/ 7/96	18 20 ca.	9/ 8/96	17 17 ca.
<i>L. picata</i>	4/30/07	18 20 ca.	.....	.....
".....	.....	.....	6/21/07	18 12 ca.
<i>G. humeralis</i>	5/13/06	16 12 to 14	5/15/06	15 0
<i>St. humilis</i>	9/14/00	13 12 to 14	9/15/00	12 21
<i>St. risoria</i>	9/13/00	14 0	9/15/00	14 0
Satinette.....	4/10/98	18 15 to 16	4/10/98	16 22 to 23
<i>P. chalcoptera</i>	1/ 3/06	17 12 ca.	1/ 4/06	16 18 to 20
".....	3/18/06	17 20 to 21	.....	.....
".....	6/ 2/06	16 12 ca.	6/ 3/06	15 18 ca.
<i>Ectopistes</i>	8/11/96	13 ca.	.....	.....
".....	5/11/97	13 ca.....	.....	.....
".....	6/12/97	12 12 to 13	.....	.....
".....	7/25/98	12 18 to 20 ¹	.....	.....
".....	8/ 2/98	12 20 ca.	.....	.....
".....	8/ 8/98	12 ca.	.....	.....
".....	8/11/98	12 12 ca.	.....	.....
".....	8/ 9/98	14 to 15 ²	.....	.....
".....	8/ 4/97	12 1 ca.	.....	.....
".....	9/ 4/97	12 12 to 18	.....	.....
".....	8/28/97	12 12 to 18	.....	.....
Ring-doves.....	3/28/95	15 18 to 20	3/28/95	13 20 ca.
".....	4/30/95	14 15 to 17	.....	.....
".....	5/28/95	14 12 ca.	5/29/95	13 20 ca.
".....	7/ 4/95	15 12 to 14	7/ 5/95	14 20 to 22
".....	8/ 9/95	14 12 to 13	8/10/95	14 5
".....	10/31/95	15 20 ca.	10/31/95	15 5 to 6
".....	1/ 6/96	15 8 to 12	1/ 6/96	14 3 $\frac{1}{2}$
Common pigeons	3/20/97	19 16 $\frac{3}{4}$	3/20/97	17 13
".....	5/ 2/97	17 22 ca.	5/ 3/97	16 14 $\frac{1}{2}$
".....	6/ 2/97	18 20 to 21	6/ 2/97	16 13 to 14
".....	8/29/97	18 12 ca.	8/29/97	16 18 ca.
".....	3/16/98	18 12 ca.	3/16/98	16 12 ca.

¹ Probably.² Incubation was intermittent, not steady.

TABLE 3.—Probable length of the incubation period—summary.

	First egg.	Second egg.
	days.	days.
Common pigeons....	18 $\frac{1}{2}$ to 19 $\frac{5}{8}$	16 $\frac{1}{2}$ to 17 $\frac{1}{2}$
Fantails.....	18 $\frac{1}{2}$	17 $\frac{1}{2}$
<i>L. picata</i>	18 $\frac{1}{2}$	18 $\frac{1}{2}$
Satinette.....	18 $\frac{1}{2}$	17
<i>P. chalcoptera</i>	17 $\frac{1}{2}$	16 $\frac{3}{4}$
<i>G. humeralis</i>	16 $\frac{1}{2}$	15+
Ring-doves.....	14 $\frac{1}{2}$ to 15 $\frac{1}{2}$	14 to 14 $\frac{1}{2}$
<i>Zenaidura</i>	14 $\frac{1}{2}$ to 15 $\frac{1}{2}$	14 $\frac{1}{2}$ to 14 $\frac{1}{2}$
<i>St. risoria</i>	14	14
<i>St. humilis</i>	13 $\frac{1}{2}$	12 $\frac{1}{2}$
<i>Ectopistes</i>	12 $\frac{1}{2}$	.....

the mating of a male *A* with a female *B* will produce eggs which will incubate in approximately 18 days, while the resultant period of a male *B* with a female *A* will be perhaps 13 or 14 days. These values are given merely for illustrative purposes. For the data, and the discussion of the phenomenon, the reader is referred to Chapter XV, Volume II.

NUMBER OF EGGS.

Most species lay two eggs; there are some, quite a number, that lay a single egg. Even those that normally lay two eggs sometimes lay but one, so that we do not need any "mutation" to get a species that lays one. I find my white-faced, or Wonga-Wonga, pigeons (*L. picata*) produce only one egg. At least this has been found several times in succession (possibly two eggs were laid in a few cases). The passenger-pigeons (*Ectopistes*) laid one egg in each of 23 cycles recorded.

The editor finds the following list, and references to the literature, of one-egg-laying species:

The following pigeons lay but 1 egg: *Dodo*, *Calænas*, *Ectopistes*, *Didunculus*, *Goura*, yellow-billed pigeon, bandtail pigeon, and some species of *Carpophaga* and *Columba*. Generally 2 eggs are laid and in exceptional cases 3 (E. Evans, Birds, The Cambridge Nat. Hist., Vol. IX, 1899, p. 328). Darwin states (Animals and Plants, II, p. 190) that *Ectopistes* invariably lays 2 eggs in America, but only 1 in Lord Derby's menagerie. The same fact is also asserted of the white-crowned pigeon. Le Souef (Emu, II, 1903, pp. 139-159) recorded *Ptilopus ewingi* (rose-crowned fruit-pigeon) and *Myristicivora spilochroa* (nutmeg pigeon) as pigeons that lay but 1 egg. He also found, in one case, but a single egg from *Lophophaps leucogaster* (white-bellied plumed pigeon), but was uncertain as to the normal number. (SS 10, Sh 8/13, SS 4, R19.)

Among the records for two-egg-laying species a single egg was noted in 8 cycles. These were found in the following pairs: *Geopelia humeralis*, passenger-ring-dove, mourning-dove-white ring, blond ring, homer, a pair of hybrids, and twice in a pair of mourning-doves.

Sometimes eggs may be lacking entirely, although the birds may unite, build a nest, give the preliminary symptoms of egg-laying, and continue with the incubation of an empty nest. This phenomenon occurred in the second cycle of a crested and ring-dove pair and in 2 cycles of another rather similar pair. For further details the reader is referred to the records given in Chapter VII, on "Defective Cycles."

TIME OF LAYING.

The first egg is dropped in the afternoon. Table 4 gives the data for 180 eggs, and there is no exception to the rule; it applies to *Ectopistes* and *L. picata*, which produce but 1 egg in a clutch, as well as to those pairs that occasionally failed to lay a second egg. The recorded times range from 3^h 30^m to 6^h 50^m, a period of approximately 3 hours. Dividing the afternoon into the two periods of before and after 5 o'clock, we find that 68 eggs were laid in the first period and 69 in the second. The more usual laying time for the first egg is thus around 5 p. m.

The time of the second egg depends upon the species, and to a slight extent upon the season. Some species invariably lay in the morning, while others

normally lay in the afternoon. The morning period ranges from 6^h 30^m to 10^h 30^m. The period of greatest activity occurs around 8^h 45^m a. m., as 54 eggs were dropped before this time and 56 were laid in the second half of the period.

The time of laying of both eggs is influenced by the length of day. It is twice recorded that the first egg seems to be laid earlier, and the second later, in the short days of cold weather than in the long days of summer. This generalization is not readily apparent from an inspection of the table, though the following summary of the data establishes its validity: Of all the first eggs dropped during the six months with the shortest days, 64 per cent were laid before 5 p. m., while 58 per cent were laid after that time during the six months with long days. During the three winter months, 71 per cent were laid before 5 p. m., while in the three summer months 54 per cent were dropped after that time. Of all the second eggs laid in the forenoon during the six months with short days, 91 per cent were laid in the second half of the period, while 57 per cent were laid in the first half of the period during the long days. In the three winter months 100 per cent were laid late, while 65 per cent were laid early during the three summer months. The time of laying is thus influenced to some extent by the length of the day, or by the season. When the egg is dropped in the afternoon, the time is hastened by the early approach of darkness in the winter, while for the morning period the time is delayed by the shortness of the day. This double effect of short days thus increases the interval between the two eggs, and one can notice in the table that the interval for any species tends to decrease with the approach of summer.

The time for the second egg, and possibly for the first egg, varies with the species. The fantails, satinettes, homers, common and crested pigeons lay the first egg rather late in the afternoon and the second somewhat earlier two days later, giving an interval of slightly less than two days. *Zenaidura* has one of the shortest intervals, laying the second egg early in the morning. The blond rings and white rings lay both eggs early, while the bronze-wing, on the contrary, is a late layer. The geopelias lay the first egg early in the afternoon and the second one late in the morning, giving them one of the longest intervals among those species that drop the second egg in the forenoon.

The eggs may also be dropped prematurely, or the time may be delayed beyond the normal period. These facts are evident from the following observations:

The female of a pair of blond rings, after preparing a nest, took her place on the perch at night and dropped an egg probably in the early morning, but the time is uncertain. I discovered a broken egg on the floor of the cage under the perch where it had probably been dropped during the night. A female white ring mated to a mourning-dove laid a soft-shelled egg from the perch in the afternoon. The female of a pair of mourning-doves dropped an egg on the floor from the perch during the night. A female homer mated with a hybrid laid her first egg normally, in the afternoon, but the second egg was dropped too early, at 11^h 40^m a. m., two days later.¹

¹ The normal period of the homer is approximately 2 days, and the author remarks that "I have never known of such a case before. I can not account for the early appearance of the second egg. The weather was unusually warm."

TABLE 4.—Time of laying.

Species.	Date of first egg.	Date of second egg.	Interval.
Bronze-wing.....	12/16/05, 5 to 6 p.m.....	12/18/05, 10 ^h 15 ^m a.m.....	da. hrs. min.
".....	1/16/06, 5 to 6 p.m.....	1/18/06, 10 05 a.m.....	1 16 ca.
".....	2/ 3/06, 5 ^h 10 ^m p.m.....	2/ 5/06, 9 55 a.m.....	1 16 45
".....	2/28/06, 5 to 6 p.m.....	3/ 2/06, 9 42 a.m.....	1 16 ca.
".....	5/ 3/06, p.m.....	5/ 5/06, 10 05 a.m.....	.....
<i>Geopelia humeralis</i>	1/22/06, 4 p.m. ca.....	1/24/06, 9 55 a.m.....	1 17 ca.
".....	1/31/06, 4 p.m. ca.....	2/ 2/06, 10 35 a.m.....	1 18 ca.
".....	2/13/06, p.m.....	2/15/06, 9 00 a.m.....	.....
".....	3/ 8/06, p.m.....	3/10/06, 8 58 a.m.....	.....

Species. ¹	Date of first egg.	Species. ¹	Date of first egg.
<i>Ectopistes</i>	7/29/96, 4 p.m. ca.....	<i>Ectopistes</i>	7/15/98, p.m.
".....	8/29/96, 4 to 5 p.m.....	".....	7/25/98, p.m.
".....	3/17/97, 4 ^h 52 ^m p.m.....	".....	7/31/98, p.m.
".....	4/ 3/97, p.m.....	".....	8/ 7/98, p.m.
".....	4/22/97, 6 ^h 25 ^m p.m.....	".....	8/22/97, p.m.
".....	4/28/97, 5 25 p.m.....	".....	8/28/97, 5 ^h 44 ^m p.m.
".....	5/23/97, 5 10 p.m.....	".....	8/15/97, 6 00 p.m.
".....	5/30/97, 5 to 6 p.m.....	White-face (<i>L. picata</i>).....	4/11/07, p.m.
".....	6/24/97, 5 p.m. ca.....	".....	5/21/07, 3 ^h 40 ^m p.m.
".....	8/16/97, p.m.....	".....	6/ 2/07, 5 p.m.
".....	7/12/98, p.m.....		

Species.	Date of first egg.	Date of second egg	Interval.
<i>Zenaidura</i>	3/24/97, 6 ^h 07 ^m p.m.....		da. hr. min.
".....	4/26/97, 5 05 p.m.....	4/28/97, 7 to 9 a.m.....	1 14 to 16
".....	5/27/97, 5 to 6 p.m.....	5/29/97, 6 ^h 35 ^m a.m.....	1 12 to 13
".....	7/14/97, 4 ^h 51 ^m p.m.....	7/16/97, a.m.....	.....
".....	8/18/97, 4 to 5 p.m.....	8/20/97, 7 to 8 ^h 30 ^m a.m.....	1 14 to 16½
".....	4/ 2/98, 5 to 6 p.m.....	No second egg.	.....
".....	4/ 9/98, 4 to 5 p.m.....	4/11/98, a.m.....	.....
".....	6/ 2/98, 4 to 5 p.m.....	6/ 4/98, 7 to 8 ^h 30 ^m a.m.....	1 14 to 16½
European turtle.....	5/31/97, 5 ^h 10 ^m p.m.....	6/ 2/97, 8 ^h 12 ^m a.m.....	1 15 2
Blond rings.....	3/12/95, 4 to 6 p.m.....	3/14/95, 8 to 9 a.m.....	1 14 to 17
".....	4/15/95, 4 to 5 p.m.....	4/17/95, 8 ^h 33 ^m a.m.....	1 15½ to 16½
".....	5/13/95, 5 ^h 30 ^m p.m.....	5/15/95, 8 15 a.m. ca.....	1 14 45 ca.
".....	6/18/95, 4 46 p.m.....	6/20/95, 8 30 a.m. ca.....	1 15 44 ca.
".....	7/25/95, 4 35 p.m.....	7/27/95, 7 36 a.m.....	1 15
".....	10/15/95, 4 to 6 p.m.....	10/17/95, 8 to 9 a.m.....	1 14 to 17
".....	12, 21/95; 3 ^h 30 ^m to 5 ^h 30 ^m p.m.....	12/23/95, 9 ^h 20 ^m a.m.....	1 16 to 18
".....	1/28/97, 5 12 p.m.....	1/30/97, 9 53 a.m.....	1 16 51
".....	3/ 4/97, 4 54 p.m.....	3/ 6/97, 9 42 a.m.....	1 16 44
".....	3/27/97, 5 05 p.m.....	3/29/97, 8 56 a.m.....	1 15 51
".....	4/27/97, 5 01 p.m.....	4/29/97, 9 08 a.m.....	1 16 7
".....	6/ 2/97, 4 43 p.m.....	6/ 4/97, 7 to 8 ^h 30 ^m a.m.....	1 14 15
".....	5/12/96, 4 50 p.m.....		.....
".....	12/23/96, 3 58 p.m.....	12/25/96, 9 ^h 18 ^m a.m.....	1 17 20
".....	3/ 5/97, 4 43 p.m.....	3/ 7/97, 8 51 a.m.....	1 16 48
".....	3/14/97, 4 27 p.m.....	3/16/97, 8 55 a.m.....	1 16 28
".....	3/27/97, 4 45 p.m.....	3/29/97, 8 37 a.m.....	1 15 52
".....	4/ 9/97, 5 00 p.m.....	4/11/97, 8 to 9 a.m.....	1 15 to 16
".....	6/ 6/97, 4 27 p.m.....	6/ 8/97, 8 ^h 12 ^m a.m.....	1 15 45
".....	11/29/96, 3 45 p.m.....		.....
".....	12/23/96, 3 45 p.m.....	12/25/96, 9 15 a.m.....	1 17 30
".....		1/17/97, 9 45 a.m.....	.....
".....	1/ 1/97, 3 53 p.m.....	1/ 3/97, 9 55 a.m.....	1 18 2
".....	3/ 6/97, 5 03 p.m.....	3/ 8/97, 9 45 a.m.....	1 16 42
".....	4/19/97, 5 31 p.m.....	4/21/97, 9 15 a.m.....	1 15 44
Common pigeon.....	2/28/97, 5 15 p.m.....	3/ 2/97, 5 30 p.m.....	2 0 15
".....	4/14/97, 5 to 5 ^h 40 ^m p.m.....	4/16/97, 4 35 p.m.....	1 23 to 23½
".....	5/14/97, p.m.....	5/16/97, p.m.....	.....
".....	8/10/97, p.m.....	8/12/97, p.m.....	.....

¹ These species lay but a single egg in each clutch.

TABLE 4.—Time of laying—Continued.

Species	Date of first egg.	Date of second egg.	Interval.
			da. hr. min.
Hyb. ring ♂ × homer ♀	6/16/97, p.m.	6/18/97, p.m.	
"	6/28/97, p.m.	6/30/97, p.m.	
"	7/13/97, 6 p.m.	7/15/97, p.m.	
"	7/29/97, 5 to 6 p.m.	7/31/97, before 6 p.m.	2 ca.
"	8/12/97, p.m.	8/14/97, p.m.	
"	8/29/97, 5 ^h 37 ^m p.m.	8/31/97, p.m.	
"	10/ 7/97, 5 20 p.m.	10/ 9/97, p.m.	
"	10/23/96, p.m.	10/25/97, p.m.	
"	12/16/97, p.m.	12/18/97, p.m.	
"	1/ 9/98, p.m.	1/11/98, p.m.	
"	2/10/98, 6 ^h 15 ^m p.m.	2/12/98, 2 ^h 55 ^m p.m.	1 20 40
Crested (<i>Ocyphaps</i>)	3/ 1/97, 4 to 6 p.m.	3/ 3/97, 4 47 p.m.	2 ca.
"	3/18/97, 4 ^h 55 ^m p.m.	3/20/97, 5 18 p.m.	2 0 23
"	7/25/96, 5 45 p.m.	7/27/96, 4 37 p.m.	1 22 52
"	3/10/97, 4 to 6 p.m.	3/12/97, 4 35 p.m.	2 ca.
"	4/ 3/97, 5 to 6 p.m.	4/ 5/97, 5 44 p.m.	2 ca.
"	4/16/97, 4 ^h 56 ^m p.m.	4/18/97, 5 39 p.m.	2 0 43
"	5/20/97, 5 43 p.m.	5/22/97, 5 38 p.m.	1 23 55
"	4/ 8/97, 4 32 p.m.	4/10/97, 5 33 p.m.	2 1 1
"	5/15/97, 6 05 p.m.	5/17/97, 5 55 p.m.	1 23 50
Zenaidura ♂ × white ring ♀	4/19/97, 4 to 6 p.m.	4/21/97, 8 to 9 a.m.	1 14 to 17
"	4/29/97, 4 ^h 05 ^m p.m.	5/ 1/97, 8 ^h 10 ^m a.m.	1 16 5
"	6/16/98, 5 05 p.m.	6/18/97, 8 05 a.m.	1 17
Blond hyb. ♂ × white ring ♀	5/ 1/97, 3 52 p.m.	5/ 3/97, 7 25 a.m.	1 15 33
"	5/10/97, 3 45 p.m.	5/12/97, 7 15 a.m.	1 15 30
"	6/ 5/97, 4 15 p.m.	6/ 7/97, 7 26 a.m.	1 15 11
"	3/23/98, 4 11 p.m.	3/25/98, 7 50 a.m.	1 15 39
White-bl. ♂ × blond-wh. hyb. ♀	5/ 9/97, 4 10 p.m.	5/11/97, 7 58 a.m.	1 15 48
"	6/11/97, 5 17 p.m.	6/13/97, 8 39 a.m.	1 15 22
"	4/30/97, 4 05 p.m.	5/ 2/97, 7 50 a.m.	1 15 45
Ectopistes ♂ × bl.-wh. hyb. ♀	3/ 1/97, 4 to 6 p.m.	3/ 3/97, 9 48 a.m.	1 16 to 17
"	3/13/97, 5 ^h 10 ^m p.m.	3/15/97, 9 02 a.m.	1 15 52
"	3/27/97, 4 50 p.m.	3/29/97, 9 07 a.m.	1 16 17
"	4/ 9/97, 5 02 p.m.	4/11/97, 8 to 9 a.m.	1 15 to 16
"	4/18/97, 4 42 p.m.	4/20/97, 8 ^h 25 ^m a.m.	1 15 43
"	4/30/97, 5 10 p.m.	5/ 2/97, 9 14 a.m.	1 16 4
"	5/10/97, 5 37 p.m.	5/12/97, 9 36 a.m.	1 15 59
"	6/ 5/97, 4 05 p.m.	6/ 7/97, 6 21 a.m.	1 14 16
"	8/13/97, 5 48 p.m.	8/15/97, 8 37 a.m.	1 14 49
"	4/ 4/98, 3 20 p.m.	4/ 6/98, 7 40 a.m.	1 16 20
"	4/15/98, 4 ^h 30 ^m to 5 ^h 30 ^m p.m.	4/17/98, a.m.	
Complex bl.-white hyb. ♀	3/22/98, 4 10 p.m.	3/24/98, 8 ^h 23 ^m a.m.	1 16 13
Zenaidura ♂ × bl.-wh. hyb. ♀	3/23/98, 4 26 p.m.	3/25/98, 8 00 a.m.	1 15 34
Common ♂ × Jap. turtle ♀	9/ 6/97, 5 to 6 p.m.	9/ 8/97, 10 ^h 15 ^m a.m.	1 16 to 17
"	10/ 6/97, 5 to 6 p.m.	10/ 8/97, 10 05 a.m.	1 16 to 17
"	12/18/97, 3 ^h 55 ^m p.m.	12/20/97, 10 05 a.m.	1 18 10
"	9/ 6/97, 4 05 p.m.	9/ 8/97, 9 50 a.m.	1 17 45
Fantail	8/19/96, 5 to 6 p.m.	8/21/96, 1 to 2 ^h 30 ^m p.m.	1 19 to 20
Satinette	3/22/98, 4 ^h 05 ^m p.m.	3/23/98, 2 ^h 30 ^m to 3 ^h 30 ^m p.m.	1 22½ to 23½
Zenaidura ♂ × ring-dove ♀	4/10/97, 5 11 p.m.	4/12/97, 8 39 a.m.	1 15 28
"	4/18/97, 5 06 p.m.	4/20/97, 8 35 a.m.	1 15 29
"	4/29/97, 4 50 p.m.	5/ 1/97, 8 28 a.m.	1 15 38
"	6/ 2/98, 4 to 5 p.m.	6/ 4/98, 7 to 8 ^h 30 ^m a.m.	1 15 ca.
"	6/16/98, 4 ^h 24 ^m p.m.	6/18/98, 7 ^h 59 ^m a.m.	1 15 35
Common ♂ × ring-dove ♀	5/ 3/96, 4 to 6 p.m.	5/ 5/96, 8 to 9 a.m.	1 14 to 17
"	5/23/96, 4 to 6 p.m.	5/25/96, 8 ^h 50 ^m a.m.	1 15 to 17
"	6/19/96, 5 to 6 p.m.	6/21/96, 9 53 a.m.	1 16 to 17
"	7/20/96, 5 ^h 30 ^m p.m.	7/22/96, 8 45 a.m. ca.	1 15 15 ca.
"	8/ 2/96, 5 30 p.m. ca.	8/ 4/96, 7 to 9 a.m.	1 14 to 16
"	8/24/96, 4 to 5 p.m.	8/26/96, 8 to 9 a.m.	1 15 to 17
"	10/11/96, 4 ^h 45 ^m p.m.	10/13/96, 8 ^h 47 ^m a.m.	1 16 2 ca.
"	10/31/96, 4 to 5 p.m.	11/ 2/96, 8 55 a.m.	1 16 to 17
"	11/30/96, 4 to 5 p.m.	12/ 2/96, 9 16 a.m.	1 16 to 17
"	12/20/96, 4 to 6 p.m.	12/22/96, 9 20 a.m.	1 15½ to 17½
"	1/23/97, 5 ^h 05 ^m p.m.	1/25/97, 10 05 a.m.	1 17
"	2/26/97, 5 04 p.m.	2/28/97, 9 28 a.m.	1 16 24
"	3/19/97, 4 42 p.m.	3/21/97, 9 16 a.m.	1 16 34
"	4/17/97, 4 to 6 p.m.	4/19/97, 7 50 a.m.	1 14 to 16
"	5/30/97, 5 ^h 08 ^m p.m.	6/ 1/97, 7 50 a.m.	1 14 42
"	6/20/97, 6 21 p.m.	6/22/97, 8 53 a.m.	1 14 32

TABLE 4.—*Time of laying*—Continued.

Species.	Date of first egg.	Date of second egg.	Interval.
Common ♂ × ring-dove ♀	7/12/97, 5 to 6 p.m.	7/14/97, 7 to 9 a.m.	1 13 to 16
"	8/22/97, 4 to 6 p.m.	Prematurely dropped.	
Jap. tumbler ♂ × ring-dove ♀	7/23/97, 5 ^h 00 ^m p.m.	7/25/97, 7 to 9 a.m.	1 14 to 16
"	8/25/97, 4 to 6 p.m.	8/27/97, 8 a.m.	1 14 to 16
"	9/26/97, p.m.	9/28/97, a.m.	
"	10/21/97, 4 ^h 08 ^m p.m.	10/23/97, a.m.	
"	12/13/97, 3 36 p.m.	12/23/97, 8 to 9 a.m.	1 16½ to 17½
"	1/20/98, 4 to 6 p.m.	1/22/98, 7 to 9 a.m.	1 13 to 17
"	2/19/98, 5 p.m.	2/21/98, a.m.	
Zenaidura ♂ × white ring ♀	1/ 8/97, 4 ^h 33 ^m p.m.	1/10/97, 9 ^h 05 ^m a.m.	1 16 32
"		3/10/97, 8 35 a.m.	
White rings	5 p.m.	8 15 a.m.	1 15 15
Common ♂ × white ring ♀	4/ 9/96, 4 ^h 14 ^m p.m.		
Homer ♂ × blond ring ♀	3/11/97, 4 45 p.m.	3/13/97, 9 16 a.m.	1 16 31
"	4/30/97, 5 29 p.m.	5/ 2/97, 9 10 a.m.	1 15 41
"	3/24/97, p.m.	No second egg.	
"	4/ 3/97, 5 ^h 02 ^m p.m.	4/ 5/97, 9 ^h 27 ^m a.m.	1 16 25
"	4/17/97, 5 15 p.m.	4/19/97, 8 52 a.m.	1 15 37
"	4/30/97, 4 50 p.m.	5/ 2/97, 7 40 a.m.	1 14 50
"	6/26/97, 5 05 p.m.	6/28/97, 7 42 a.m.	1 14 37
"	6/ 5/97, 4 39 p.m.	6/ 7/97, 7 55 a.m.	1 15 16
"	8/13/97, 6 50 p.m.	8/15/97, 8 45 a.m.	1 13 55
Zenaidura ♂ × blond ring ♀	6/ 3/98, 4 to 5 ^h 30 ^m p.m.	6/ 5/98, 7 to 8 a.m.	ca.1 15 (short)
"	6/16/98, 4 ^h 18 ^m p.m.	6/18/98, 7 ^h 50 ^m a.m.	1 15 32
Archangel ♂ × blond ring ♀	2/18/97, 4 to 4 ^h 30 ^m p.m.	2/20/97, 9 29 a.m.	1 17 29?
"	3/14/97, 4 ^h 55 ^m p.m.	3/16/97, 10 30 a.m.	1 17 35
"	5/11/97, 5 26 p.m.	5/13/97, 8 45 a.m.	1 15 19
"	6/ 6/97, 5 27 p.m.	6/ 8/97, 8 57 a.m.	1 15 30
"	6/26/97, 5 37 p.m.	6/28/97, 9 11 a.m.	1 15 34
"	8/ 2/97, 5 48 p.m.	8/ 4/97, 8 37 a.m.	1 14 49
"	8/29/97, 5 34 p.m.	8/31/97, 8 50 a.m.	1 15 16
Common ♂ × blond ring ♀	1/12/98, 4 to 6 p.m.	1/14/98, 7 to 9 a.m.	1 13 to 17
Blond hyb. ♂ × blond ring ♀	3/22/98, 4 ^h 20 ^m p.m.	3/24/98, 8 ^h 23 ^m a.m.	1 16 18
White fantail ♂ × ring-dove ♀		1/ 2/97, 9 48 a.m.	
"	2/14/97, 3 ^h 30 ^m to 4 ^h 30 ^m p.m.	2/16/97, 9 10 a.m.	1 17 ca.
"	4/17/97, 4 58 p.m.	4/19/97, 7 43 a.m.	1 14 45
"	5/ 9/97, 4 34 p.m.	5/11/97, 8 43 a.m.	1 16 9
"	5/31/97, 5 10 p.m.	6/ 2/97, 7 42 a.m.	1 14 32
"	7/31/97, 4 16 p.m.	8/ 2/97, 7 45 a.m.	1 15 29
Crested ♂ × ring-dove ♀		2/26/97, 8 34 a.m.	1 15 to 16
"	3/24/97, 5 p.m.	3/26/97, 8 40 a.m.	1 15 40
"	4/ 5/97, 4 to 5 ^h 10 ^m p.m.	4/ 7/97, 8 15 a.m.	1 14 to 15
"	4/17/97, 4 ^h 05 ^m p.m.	4/19/97, 7 46 a.m.	1 15 41
"	5/ 1/97, 4 37 p.m.	5/ 3/97, 8 31 a.m.	1 15 54
"	5/15/97, 4 35 p.m.	5/17/97, 7 17 a.m.	1 14 42
"	6/27/97, 4 34 p.m.	6/29/97, 7 15 a.m.	1 14 41

A female ring-dove mated with a common pigeon dropped her second egg at 6^h 20^m p. m., only a little more than one day after laying the first. This was due to rough treatment. I found her off the nest and the young hybrid on the egg. I tried to have her return to the nest, but she kept leaving the egg and tried to get away. As she flew from me I tried to catch her, and in the effort my hand struck on her back, forcing her to the ground. The blow was not hard, but it must have jarred her, and within 5 to 10 minutes afterward she dropped the second egg, which had a shell which was still quite thin and which was broken when I discovered it. The female of a pair of blond × white rings laid the second egg between 11 and 12 o'clock but this was a case where the time was evidently delayed on account of moving the doves into the house, and the egg was not laid until the nest was returned to its place in the coop at the rear of the house. This case would not count as normal. (R19, Em 7, C 7/7.)

The time of laying the second egg may occasionally be influenced by the male's incubation activities. He occupies the nest during the day and frequently begins

incubation before the arrival of the second egg. He may thus occupy the nest at the usual time and refuse to leave on the demand of the female. (See Early Incubation, Chapter V.)

BEHAVIOR IN LAYING.

A few days before laying the female blond ring shows symptoms which are peculiar and diagnostic. The wings are held loosely and allowed often to drop below the tail. The bird looks as if sick, and moves about heavily and with unusual care. She usually sits in the nest more or less for from 3 to 4 days before laying. The white ring-doves behave in the same way.

At 9 a. m., I watched one of my blond ring-doves lay her second egg. Sitting at my desk, I happened to notice that the bird had taken an attitude as if in the act of laying. On going close to the nest I found that I was not mistaken. The bird was standing with head straight up and the hind end of the body lowered, almost touching the bottom of the nest. She was evidently in some pain and appeared to be struggling to deliver the egg. As the egg came the head was thrown back and turned half way round, with eye-lids closed, in the agony of sharp pain. That it cost pain was evident by a mark of blood on the egg and by the swollen, bloody appearance of the lips of the anus. For some moments after the egg was delivered the bird continued standing, without moving, so that I could see both eggs under her. At length she seemed to recover, put her head down far enough to look at the eggs, put her beak under the new-laid egg with care and fondness, and finally settled down over them, appearing to be somewhat exhausted with the effort. Some 5 weeks after the above observations were made I saw the "supposed male" of this pair lay an egg; it behaved in the same way, except that it did not exhibit any agony, but merely a severe strain.

A crested pigeon mated with a magpie laid her first egg at 4^h 35^m to 4^h 37^m p. m. She sat upright with tail above her wings. She gave the call-note almost continuously just before laying. She had a hard task to deliver the egg, making repeated efforts, and succeeded only at the end of 2 minutes after her first effort. The egg was not above the usual size for this species.

An *Ectopistes* was observed in laying an egg at 5^h 25^m p. m. She moved forward in the nest and held herself in a more or less erect position. When she dropped the egg she lifted her wings a little, just as I saw her do in laying a previous egg. Another *Ectopistes* female stood up for 5 minutes after laying and then sat on the egg. She gave a few low calls shortly before laying.

In laying her second egg a mourning-dove sat up erect, as does the ring-dove, with her tail raised between the ends of her wings. *The small end of the egg came first.* This bird gave a low call several times just before she took a position to lay. This call was the usual call to nest-making.

A female bronze-wing, at 9^h 41^m a. m., began to take a position for laying; that is, she stood a little in front of the middle of the nest, so that the coming egg would be placed in the middle. She then raised her head and the fore part of the body and lowered the hind part with the axis of the body inclined at about 45°; she made one or two efforts to drop the egg, then finally lowered the body and laid the egg beside the first so carefully as not to give it any jar. The egg came small end first and was left for a moment standing on this end.¹

A white dove was observed while laying an egg at 4^h 15^m p. m. She gradually raised the fore-body and head, leaning back as if partly supported by the tail. As the egg came

¹"The small end generally comes first, with occasional exceptions. A single exception disproves the idea that form is due to mechanical causes. Form is due to *self-differentiation of the egg-cell*," says W. V. Nathusius (Archiv. f. Entw'mech. d. Organismus, VI, 1898), but the author does not agree.

the head was thrown back with a slight jerk, followed by a second jerk as the egg dropped. The whole operation lasted about 30 seconds. The dove then continued standing and closed her eyes as if in sleep for a few moments. After a lapse of a few minutes she lowered herself over the egg and went on sleeping.

At precisely 4^h 50^m p. m., the female of a pair of ring-doves laid her first egg. I first noticed the bird sitting upright in the usual position. In the course of half a minute the egg was dropped, and just as it came the head was thrown back and turned momentarily to one side, with an evident strain. After the egg was dropped the bird remained standing over it, barely touching it above with her feathers, for nearly an hour (4^h 50^m to 5^h 45^m); then she settled down and covered it so that it could no longer be seen. This is the same as I have before described in another female, and I am now sure that it is the usual thing. The bird appeared to go to sleep soon after dropping the egg, and remained quiet most of the time, though closing the eyes only occasionally. The small end of the egg always comes first. I have seen this in several cases.

I saw the second egg laid at 8^h 50^m a. m. The female moved about a good deal, preparing her nest and getting ready for oviposition. At length she took the usual position and dropped the egg in not over 15 seconds. As the egg dropped she toppled forward as if she had lost her balance. The head was thrown back and twitched once or twice as the egg passed.

The egg-laying of the crested pigeon was observed. The bird sat upright in the nest and spent 2 to 5 minutes in laying the egg. She made plain efforts, one following the other at little intervals, to relieve herself of the egg. I have seen the same bird lay another egg, and she behaved in the same way. After laying she stood up for about 10 minutes only, then sat down on the egg and went to sleep.

I saw the first and second eggs laid in the case of a pair of blond ring-doves. A crested pigeon laid her second egg at the same time the female blond ring laid her first egg, and I gave my attention mostly to the former. The laying of the second egg by the blond ring was carefully watched. In this latter case the female took the usual position and spent about half a minute in laying. She made several efforts, and the final one caused her to throw her head back and then turn it to one side as if in pain. She stood over the eggs during 8 minutes and then sat down upon them. In case of the first egg she stood 15 minutes before sitting down. The crested pigeon stood for 10 minutes over the second egg before sitting.

The female of a pair of ring-doves laid her first egg at 6^h 05^m p. m. The time taken, from the moment when she began to stand upright, was 50 seconds. The bird showed plainly that she made efforts at short intervals, and the final effort was marked by the usual behavior. She stood over the egg 9 minutes, then left the nest to eat; she returned after 3 minutes, looked at the egg, appeared to hesitate about sitting, and after standing 8 minutes came off and went outside. The male went in and sat a moment, but soon left. The female returned a little later and stood beside the egg. She finally took the perch and remained away from the egg all night. The following morning I found the egg warm, showing that one of the birds had been on the nest. But they were sometimes both off at one time and were irregular in sitting.

Another female crested pigeon in laying an egg took the nest a few minutes before 5 p. m. She then gave the call-note, which answers for a "coo," several times. She again gave this same note several times while fixing herself upright for laying and while in the upright position, and only ceased a moment before she was ready to drop the egg, which she did at 5^h 18^m p. m.

The female of a pair of mourning-doves laid a first egg at 6^h 07^m p. m. In laying she sat about as nearly upright as the ring-dove does, and at the moment of dropping the egg she gave her head a turn to one side with her beak raised, not vertically, but at an angle

of about 45°. She spent about a minute in laying and made vigorous efforts at short intervals to expel the egg. As soon as it was dropped she took a standing position over it for about 20 minutes and then flew up to the perch. At about 7 p. m. I found her sitting on the egg.

I expected two females of two pairs of ring-dove females (*L 2* and *GF 1*) mated to crested males to lay for the "first time in life." I found both on their nests at 3^h 50^m, and kept watch of them in order to get the exact time. Both behaved as if they were just ready to lay. Female *L 2* remained on the nest until 5^h 30^m, came off for a minute, returned, and came off again in about a minute. She went back almost immediately, but stopped on the edge of the nest-box. Here she sat quietly until 7^h 25^m, when, frightened by something, probably an owl appearing before the window, she flew to the floor and her mate flew to another corner of the pen. After a few minutes she went back to the edge of the nest-box, where she remained all night, returning to the nest early in the morning. Female *GF 1* came off the nest at 4^h 30^m, flew to the floor, and then took her place on the perch beside her mate until 5^h 45^m, when she went to the nest-box and sat quietly until 7^h 50^m; at this time she got up on the edge of the nest-box and soon after stepped upon the perch close by, where she remained all night, returning to the nest early the following morning.

These two females evidently went through the preliminaries to laying, but they were a little premature in their actions. By experience they will learn to waste less time in fruitless formalities and make less ado over such a small matter as laying an egg. After 10 days there are no eggs from either of these females, but *GF 1* has been busy during the mornings of nearly every day, and to-day her wings droop, showing that she is about ready to try to lay. Female *L 2* has spent less time on the nest, and sometimes seems to have given up nesting for the present. On the following day *GF 1* began to incubate the empty nest, *i.e.*, without having laid, and *L 2* did not lay until 17 days after an egg was expected. The act was not observed. (R 19, SS 4, R 33.)

TIME OF HATCHING.

I have observed one or two interesting things in regard to the time of hatching. I have noted that young birds never hatch, or very rarely, after 3 o'clock in the afternoon; they usually hatch early in the morning. If not early in the morning, then between 10 a. m. and 12 noon. If not within these latter hours there is, as a rule, no hatching between 12 noon and 1 p. m. There may be now and then exceptions, of course, but if the egg does not hatch by 3 p. m. one can be fairly certain that nothing will be done until the next morning. It may be fully time for the bird to hatch, but for some reason the hatching is not completed and the *bird goes to sleep*, apparently rests, and then wakes up very early with the rest of the birds in the morning and concludes the hatch. I have timed this phenomenon and watched so closely that I feel very certain that the bird, before hatching, has his time of resting, and that these times correspond to the times of rest in the old birds. In the middle of the day the birds are always very quiet and resting; the bird in the shell remains quiet also.¹ (SS 10.)

The data of the available records are given in Table 5. These figures support the above statements. Of the 113 cases, only 83 are definite enough to be utilized.

¹ The prenatal behavior of the pigeon ought to be studied. The young bird goes to sleep and awakens regularly, and thus it is determined that it shall not hatch out at an improper time. Hatching takes place early in the morning, or sometimes toward noon. It is very rarely, and only in the case of some delay, that a bird hatches out as late as 2 o'clock. I have known a bird to have performed a great part of the work of opening the shell and then go to sleep and wait till the next morning. I suppose they "know the time" by the regular recurrence of their own activities, and by its being the time of greatest activity of the parent birds. The young bird usually first cracks the egg about 24 hours before emerging. It begins to work about 5 a. m. and continues till perhaps 11 a. m., when it takes a noonday rest. The parents rest from about 11 to 1 o'clock. (Conv. 7/20/10, W. C.)

TABLE 5.—Time of hatching.

Species.	First egg.	Second egg.
<i>Zenaidura</i>	5/11, 3 p.m.	5/13, before 5 ^h 30 ^m a.m.
".....	6/11, 1 to 2 p.m.	6/12, 8 ^h 15 ^m a.m.
".....	7/29, 1 ^h 20 ^m p.m.	7/30, 1 to 2 p.m.
".....	9/ 2, 6 a.m.	9/ 2, 10 ^h 12 ^m a.m.
".....	5/ 8, a.m.	
".....	6/18, before 5 a.m.	6/19, 4 to 6 a.m.
".....	7/18, 7 a.m. to 2 p.m.	7/19, early a.m.
".....	8/15, early a.m.	8/16, early a.m.
".....	8/13, p.m.	8/14, before 1 p.m.
".....	5/18, a.m.	5/19, early a.m.
".....	6/26, early a.m.	6/26, before 1 p.m.
".....		7/27, a.m.
Fantail.....	9/ 7, 1 ^h 15 ^m p.m.	9/ 8, before 7 a.m.
<i>L. picata</i>	4/30, 1 15 p.m.	
".....	6/21, before 6 a.m.	
<i>Ectopistes</i>	8/11, before 2 p.m.	
".....	5/11, 2 to 3 p.m.	
".....	6/12, a.m.	
".....	7/25, 1 to 2 p.m.	
".....	8/ 2, 1 to 2 p.m.	
".....	8/ 8, 2 ^h 30 ^m to 3 p.m.	
".....	8/11, before 7 a.m.	
".....	8/ 9, after 8 ^h 30 ^m a.m.	
".....	8/ 4, before 2 ^h 30 ^m p.m.	
".....	9/ 4, before 1 p.m.	
Bronze-wing.....	1/ 3, 5 ^h 30 ^m to 6 ^h 30 ^m a.m.	1/ 4, 4 to 6 a.m.
".....	3/18, 2 to 3 p.m.	
".....	6/ 2, early a.m.	6/ 3, early a.m.
<i>G. humeralis</i>	5/13, early a.m.	5/15, a.m.
<i>St. humilis</i> (red ring).....	9/14, 5 to 6 a.m.	9/15, 5 to 6 a.m.
<i>St. risoria</i> (blond ring).....		9/15
Common pigeon ♂× ring-dove ♀.....	6/18, 11 to 12 a.m.	
".....	1/ 5, before 6 a.m.	
".....		11/17, 12 m.
".....		2/ 9, before 6 a.m.
".....	4/ 4, 5 to 6 a.m.	
".....	7/28, 5 to 6 a.m.	7/29, 5 to 6 a.m.
<i>Ectopistes</i> ♂× ring-dove ♀.....	3/16, 8 a.m.	
".....		4/12, 6 ^h 10 ^m a.m.
".....	4/24, 6 ^h 50 ^m a.m.	
".....		5/ 4, 4 to 5 a.m.
".....	5/14, 1 ^h 50 ^m p.m.	5/15, 3 ^h 41 ^m p.m.
".....		5/29, 4 to 5 a.m.
".....	8/19, 6 a.m.	
".....	4/ 9, 1 to 2 p.m.	4/11, 6 a.m.
Jap. tumbler ♂× ring-dove ♀.....		8/ 8, 1 to 2 p.m.
".....	9/10, 5 to 6 a.m.	
".....	11/ 6, 1 p.m.	
".....	12/30, 7 a.m.	12/30, 6 a.m.
".....		2/ 6, a.m.
".....	3/ 7, 12 to 1 p.m.	
Archangel ♂× ring-dove ♀.....	3/ 6, 11 to 12 a.m.	3/ 7, 5 to 6 a.m.
Ring ♂× homer ♀.....	1/27, 9 a.m.	
".....		2/28, 3 ^h 30 ^m to 4 a.m.
<i>Ectopistes</i> ♂× ring hybrid ♀.....		4/20, 4 to 5 a.m.
".....	5/ 1, 5 a.m.	
Fantail ♂× ring ♀.....		5/ 4, 7 ^h 30 ^m a.m.
Homer ♂× ring ♀.....	3/27, 12 m.	3/28, 5 to 6 a.m.
".....	5/16, 5 to 6 a.m.	5/17, 5 to 6 a.m.
".....	6/21, 5 ^h 30 ^m a.m.	
".....	8/29, 5 to 6 a.m.	
".....	9/20, 12 ^h 30 ^m p.m.	
Ring ♂× homer ♀.....	1/27, 9 a.m.	
".....		2/28, 3 ^h 30 ^m to 4 a.m.
Satinette.....	4/10, 7 to 8 a.m.	4/10, 1 to 2 p.m.
Common pigeon.....	3/20, 10 ^h 08 ^m a.m.	3/20, 6 ^h 35 ^m a.m.
".....	5/ 2, 3 20 p.m.	5/ 3, 7 08, a.m.
".....	6/ 2, 1 40 p.m.	6/ 2, 6 20 a.m.
".....	8/29, 5 to 6 a.m.	8/29, 12 to 1 p.m.
".....		1/23, 12 m.
".....	3/16, 4 to 6 a.m.	3/16, 6 to 7 a.m.
Ring-doves.....	3/28, 12 to 6 p.m.	3/28, 12 to 6 p.m.
".....	4/30, 5 to 7 a.m.	
".....	5/28, 5 to 7 a.m.	5/29, 5 to 7 a.m.
".....	7/ 4, a.m.	7/15, a.m.
".....	8/ 9, 5 to 6 a.m.	8/10, 12 ^h 30 ^m p.m.
".....	10/31, 10 a.m.	10/31, 2 p.m.
".....	1/ 6, 12 to 3 ^h 30 ^m p.m.	1/ 6, 2 p.m.
".....	3/ 7, 5 to 6 a.m.	

52 occurred before 9 a. m., 5 between 9 and 12 a. m., 4 between 12 and 1 p. m., 19 between 1 and 4 p. m., and 3 at noon. The proportion of morning hatchings is greater for the second egg than for the first. Of the 34 cases in which the data are given for both eggs of the clutch, 11 pairs were hatched on the same day, 20 on successive days, and 3 on alternate days. These data illustrate once more the fact that the incubation period of the second egg tends on the whole to be the shorter; but this phenomenon can not be due *wholly* to the irregularity of early incubation, because in 4 cases the second egg was hatched first, unless we suppose that the irregularity of incubation not only prevents but positively *checks* the development of the first egg.

METHOD OF HATCHING.

In hatching, the shell is broken pretty evenly around its large end, so that this is often completely severed, but it sometimes adheres to the body of the shell at one point, and then when the young gets free this cap-like part is often turned into the larger part of the emptied shell. The break in the shell in one case, was 23 to 25 mm. from the small end, or 7 to 9 mm. from the large end. This is the usual way in all pigeons' eggs. Only in a few cases have I seen the break nearer the small end than the large end. The egg is usually first pricked about 24 hours or more before the young liberates itself. (R 33.)

INCREASED INTEREST AT HATCHING.

Both birds exhibit an increase of interest in the nest at hatching-time. This is not necessarily due to the presence of the young, as it may manifest itself before the eggs are hatched. The phenomenon is mentioned but briefly in several of the records.

The first egg of a pair was hatched between 5^h 30^m and 6^h 30^m a. m. At 9^h 50^m it was noted that the female has not once left the nest, evidently having an increased interest in the contents of the nest. At 11^h 15^m the male, after calling for 2 or 3 minutes on the floor, went to the nest, but the female was loath to leave and he again retired. The female was not off the nest to evacuate during the whole morning, thus showing how much the young has increased her interest in the nest.¹ At 1^h 05^m p. m. the male went to the nest and the female resigned for the first time.

At 10^h 45^m a. m. it was noted that the male of a pair of bronze-wings had been trying to get over the eggs for an hour, but the female kept solidly to the nest. Both were evidently ready for the young to hatch. At 2^h 30^m p. m., I helped the young bird out of the shell; it was evidently ready to emerge and was impeded by a little unnatural drying and sticking to the shell as a result of an injury on the previous day. On another occasion it was noted that, at the time the young was due to hatch, this male was very attentive and anxious to have the nest and its care. Indeed, he appeared to be remarkably solicitous, and he not only tried to get the nest, but called quite a number of times while sitting beside the female, as if he wanted to feed the young before it was quite out of the shell.

A male mourning-dove sat beside the female most of the time for 3 days before the hatching of the young. The female seemed loath to leave her nest for more than a short time. The male continued to sit close beside the female for 2 days after the first egg was hatched. (R 33, Em 7.)

¹ Normally the female leaves the nest early in the morning, before the first relief by the male, evacuates the cloaca, and then resumes her duty.—EDITOR.

CHAPTER V.

INCUBATION BEHAVIOR.

The time of beginning incubation is not always synchronous with the appearance of the first egg; it differs for the two birds, it varies with the species, and it seems to be highly variable within a species. The early incubation is often irregular, but in the later stages the eggs are covered almost continuously. Copulation ceases with the advent of the eggs, but nest-building is continued for the first half of the period. Both birds participate in the incubation of the eggs. At night the female covers the eggs, while the male normally roosts on the perch as far from the nest as possible. During the day the male and female alternate in the task, though the male occupies the nest the major portion of this time. These activities are described in detail under the topics which follow.

EARLY INCUBATION.

The wild passenger-pigeon (*Ectopistes*) begins to incubate a day or two in advance of laying, and the male takes his turn on the nest just as if the eggs were already there. In the common pigeon the sitting usually begins with the first egg, but the birds do not sit steadily or closely until the second egg is laid. The birds do not, in fact, really sit on the first egg, but merely stand over it, stooping just enough to touch the egg with the feathers. This peculiarity has an advantage in that the development of the first egg is delayed so that both eggs may hatch more nearly together.¹

A female passenger-pigeon began to make a nest on a Monday. She sat much on that day and almost constantly all day on Tuesday. She was sitting again on Wednesday; on this latter date the male seemed to be off duty and did not come near the female on the nest, although he sat for a long time on the nest during the middle of Monday and Tuesday. The egg was laid after 4 p. m. on Wednesday. In another instance, a female passenger-pigeon was on the nest in the early morning. The male sat during the middle of the day, as if he were in charge of an egg, though the nest was empty. I found the female on the nest at 3 p. m., and she remained on from this time, laying her egg at 4^h 52^m p. m. of this same day. In still another case a pair of passengers accepted a nest on one day. On the next, I saw the male on the nest at 11^h 30^m a. m., and he remained there until 3 or 4 o'clock, or perhaps until later. The egg was laid that day between 4 and 5 p. m. (SS 4.)

Fulton (*op. cit.*, p. 41) comments upon this subject as follows:

"As a rule, it is found that the sooner pigeons' eggs are allowed to commence the process of incubation after being laid the better, certainly not later than 5 or 6 days. Further, as to the time during which they may be allowed to remain uncovered after incubation has once commenced, this is regulated by the stage which has been reached. In the early days eggs may have become cold and remained so for 24 hours, and even more, and yet not be injured; but as the date of hatching approaches even 1 or 2 hours of desertion by the covering bird may cause the egg-tenant to perish; though even within 24 hours of the time of hatching we have known marvelous instances of the vital power of squabs being preserved, even though the egg may have been stone-cold for a few hours."

On the third day of incubation, *i. e.*, on the day of the laying of the second egg, a pair of bronze-wings were in full swing proceeding in regular order with incubation, not leaving the nest except by exchange of relief, and sitting (not standing). The day following the laying of the first egg was one of fairly regular incubation, but the sitting was not

¹ Woods Hole Biological Lecture, p. 327.

quite so close; the egg was left uncovered once or twice when both birds went to feed together. (R 33.)

In various records it is noted that the female bronze-wing *stood* over the first egg until the second was laid, and that she did not really sit. The female of a crested × blond ring pair also "stood" over the egg the first night. A female geopelia left the nest at 4^h 15^m p. m. and roosted on the perch beside the male the night before the second egg was laid. No record was given for the first night. In another cycle this same female roosted on the perch during the first night. The female of a second crested × blond ring pair "stood" over the first egg until the second egg was laid. A bronze-wing male began incubation on the second day of one cycle and on the third day of another. A male white ring sat on the egg the first night it was laid. A male crested pigeon began incubation on the second day, a male geopelia on the third day, and another male crested on the third day after the second egg was laid.

Since the second egg may be laid as late as 10 a. m. on the third day of the incubation period, it is possible that the male's participation in incubation may interfere with this function. Sometimes the male does not begin to participate until after this event. This means no relief for the female during the second day and a postponement of the first relief on the third day several hours later than the normal time. This was true for two of the pairs (bronze-wing and crested) mentioned above. In the first and third cycles of a pair of bronze-wings the male participated in the incubation regularly on the second day. On the third day he relieved the female for some time during the early morning, but the female had the nest at the usual time for the dropping of the second egg. Two cases are also recorded in which the male's tendency to relieve interfered with the female's duties. In the bronze-wing's fourth cycle the male relieved early in the morning. At the time for laying, the male attempted to sit and made some trouble, but the female refused to resign until after the egg was laid. In the second cycle of a crested × blond ring pair the first egg was laid at the usual time and the male participated regularly in the incubation on the second day. On the third day, the date of laying of the second egg, the male relieved at 6^h 40^m, 8^h 10^m, and 8^h 59^m. At 9^h 10^m the female crowded into the nest and forced the male off. The male relieved again, and the female returned at 9^h 17^m, but the male refused to leave. The female returned at 9^h 19^m, crowding herself on while the male yielded reluctantly. At 9^h 25^m the male was sitting beside the female and trying to take the nest, but the female refused to resign and laid at 9^h 48^m a. m. The male was back at the nest at 9^h 55^m, but the female did not resign for several minutes. The author notes that "this male's instinct is not attuned to the needs of the female in laying the second egg. I had to keep the male away from the nest, as he insisted on taking possession several times just as the female was about to lay."

TYPICAL INCUBATION RECORDS.

The various excerpts and the data on incubation have been taken from the detailed daily records. As illustrative of the nature and detail of these observations, the two following daily records are given as typical.

At 6^h 19^m a. m., Dec. 22, 1906, the female bronze-wing came off the nest to the perch to discharge her load; this being done, she went back to the nest. At 6^h 30^m the male came down to the floor for seed, but soon went back to the perch. At 6^h 32^m the male gave two calls, but I can see no reason for it. The female made no response. At 6^h 34^m the male was again on the floor trying to get into the next pen, running back and forth along the wire-netting partition. He sees a green-wing (*Lophophaps*) eating in the next pen, and this incites him to try to get through. At 6^h 39^m the male again gave two calls, nodding his head strongly with each call as usual, and then flew to the perch with his landing call. At 6^h 41^m he again went to the floor and to the seed-dish. I put fresh seed in dish at 6^h 48^m and the male came at once for his breakfast. On returning from my own breakfast at 8 a. m. I found the male on the nest and the female on the floor. At 8^h 20^m the male called three times and the female went to the nest and the male came down to feed. Probably feeding him early (at 6^h 48^m) led to his taking the nest. At 8^h 26^m the male returned to the nest and the female was again on the floor. The male resumed nest duty and in a moment or two gave two calls which were not answered. At 9^h 26^m the male gave one loud call. The female was still on the floor and gave no answer. At 9^h 28^m the male gave one loud call, no answer; the female was tramping about. Perhaps the female's noise incited the male to call. At 12^h 13^m the female relieved and the male went to the floor. During this morning the male relieved twice: 8 to 8^h 20^m and 8^h 26^m to 12^h 13^m. Since the female once held the nest only 6 minutes, the male's two times count really for once. The sun rose on this date at 7^h 17^m, and set at 4^h 23^m. (R33.)

On Feb. 12, the male went on the nest at 7 a. m.; he left the nest at 7^h 12^m and carried straw to the female. He took the nest at 8^h 50^m and came off at 9^h 06^m, the female going on at 9^h 07^m. The female came off at 9^h 20^m, and the male went immediately to the nest. At 9^h 37^m the male was off, but soon returned with a straw; he was off again at 9^h 42^m and brought a straw to the female, which had at once taken the nest. The male resumed the nest at 11^h 25^m and the female came off at 11^h 26^m; the male followed at 11^h 28^m, went back at 12^h 03^m and came off at 12^h 18^m. At 1^h 20^m the male took the nest and stayed until 2^h 05^m; the female went on at 2^h 06^m. She was relieved at 2^h 50^m by the male, which kept the nest until 3^h 07^m; the female went on 2 minutes later. The male relieved from 3^h 15^m to 3^h 33^m, and the female went on for the night at 3^h 35^m. (R 18.)

ROOSTING HABITS.

Before the eggs are laid, both birds sit together at night; after the first egg is laid the male sits at night as far away from the female as is possible.

A male crested pigeon mated with a ring-dove took up his place every night on the perch at the corner farthest from the nest-box where the female was sitting. Up to the time of laying both were accustomed to sit together on the edge of the nest-box. The male changed his sleeping place the first night after an egg was laid.

This instinct seems to be general among all species. It is the more remarkable in those social pigeons, like the crested pigeons and geopelias, which are so fond of roosting together. To-night the female of a pair of *G. humeralis* has laid an egg and is sitting on it. Her mate sits at the opposite side of the pen all alone. It would seem as if this was great self-denial, for the two have been roosting together constantly and they appear to take great pleasure in each other's company. The male sees his mate, makes loving little calls, and adds those movements of the head and beak which seem to say "come here and I will fondle your head." The female remains faithful to the egg and makes no response. The male does not yield to his desire for his mate—to go and sit beside her—but remains at the greatest distance possible. Does he have any idea of why he must deny this pleasure? In the native state his action would mean that the nest is safer if he remains away from it. But, of course, in a small pen of a few feet the distance is nothing and the sitting apart has no sense. Something moves the bird to do thus, but what? Has his love cooled?

No; for he calls for his mate and he is as loving as ever. I can think of no reason or feeling that should move him to sleep apart from his mate. But certain it is that from the moment he sees his mate on the nest, he keeps away from her at night and also in the day, except when he wants to sit. It is curious and mysterious. How could such an instinct arise? Suppose birds have been accustomed to sleep in a certain place; that is enough to establish a strong preference for the place. If the female has laid her egg in a nest in some other place, the male will have two desires—one to roost in the old place and one to go to the female. If the two motives were equally strong, the male might do either. But natural selection would favor those that remained away from the nest. (B 2c, R 17, R 33.)

Deviation from normal conduct is characteristic of the male's attempt to break up the incubation cycle. Such behavior was frequently noted in the daily record of several incomplete incubations. The male sits on the perch close to the nest-box, sits on the edge of the nest-box, or may attempt to crowd the female off the nest. This tendency was associated with many other deviations from normal masculine behavior—such as refusal to participate in incubation during the day, attempts at copulation, etc. For further details the reader is referred to the excerpts from the incubation records given in Chapter VII.

The first egg of the season was laid by a passenger \times blond-ring pair at 4 p. m. The female remained over the egg that night. The next night, at 8 o'clock, I found the male on the nest and the female on the perch. I can not say how it happened. Possibly the light in the room led the male bird to think it was morning and so he went on to relieve the female. It may be that he is again beginning his irregular sitting of last year. When I drove the male passenger off and put the female on the nest he did not try to return. This male passenger-pigeon sat on the eggs regularly of nights, the female meanwhile sitting on the edge of the nest-box. (R 17.)

ALTERNATION.

Fulton, on page 36 of his work previously cited, made the following statements, which apply to fancy or domestic pigeons:

"And now the merits of her mate grow apparent. He does not leave his lady to bear a solitary burden of matrimonial care, while he has indulged in the pleasures only of their union. He takes a share, though a minor one, of the task of incubating; and he more than performs his half share of the labour of rearing the young. At about noon, sometimes earlier, the hens leave their nests for air and exercise as well as food, and the cocks take their place upon the eggs. If you enter a pigeon loft at about 2 o'clock in the afternoon you will find all of the cock-birds sitting—a family arrangement that affords an easy method of discovering which birds are paired with which. The ladies are to be seen taking their respective turns in the same locations early in the morning, in the evening, and all the night. The older a cock-pigeon grows, the more fatherly does he become. So great is his fondness for having a rising family that an experienced unmated cock-bird, if he can but induce some flighty young hen to lay him a couple of eggs as a great favor, will almost entirely take the charge of hatching and rearing them by himself."

A female passenger-pigeon left her egg at 9 a. m. to feed for a few moments. The male saw her, but did not offer to sit. She soon returned and sat until about 10 o'clock, when he came and relieved her. She remained off until 4 p. m., then flew to the nest, but soon walked off to a perch near by when the male did not resign. At 4^h 18^m the male, after bowing a few times in recognition of his mate or to invite her to take the nest, walked off and flew to the farther end of the cot; she at once took her place on the nest. It was interesting to see the males of several varieties—two fantails, an owl-pigeon, and a common dove—all resigning their nest at about the same time, *i.e.*, about 4 p. m.

A crested male relieved his blond-ring female between 6^h 50^m and 8^h 40^m in the morning and relinquished the nest for the night between 2^h 40^m and 4^h 15^m in the afternoon. The average time of relief in the morning was 7^h 30^m, and the average time in the afternoon was 3^h 30^m. The total time during the day devoted to incubation by the male varies from 2½ hours to 8¾ hours; the average period being 6 hours daily. During the period of alternation (daytime) the male occupied the nest three times as long as the female. The number of reliefs by the male during the day varies from 1 to 9, with an average number of 3½. The length of time spent on the nest in these reliefs varies from 1 minute to 6½ hours. There were 8 intervals of 4 to 7 hours, 23 intervals of 1 to 3 hours, and 25 intervals of less than 1 hour in length. As a general rule the early reliefs were short and the later reliefs rather long.

A bronze-wing male began relief between 7 and 8^h 45^m in the morning, the average time being at 8 a. m. He retired for the night from 12^h 15^m to 3^h 20^m in the afternoon, the average time being at 2 p. m. The average number of reliefs during the day were two. The total time spent on the nest during the day varied from 3½ to 6¾ hours; the average being 5½ hours. The shorter intervals of relief occurred in the morning, while the later periods were generally the longer ones. (SS 4, R 18, R 33.)

The time of early-morning relief, as well as the time when the male retires for the night, is probably influenced by light conditions, such as the length of the day, clear or cloudy weather, etc. The bronze-wing male put in a shorter day than did one of the passenger males of the first pair; his early-morning relief averaged a half-hour later, while he retired for the night much earlier. He also spent less actual time on the nest during the day. The bronze-wing record covered the period from Dec. 16, 1905, to Jan. 3, 1906; the passenger record concerns incubation during February, when the days were appreciably longer. The daily records sometime state the character of the weather, but the cases are too few to allow of any conclusions as to the effect of the clearness or cloudiness of the day. In the bronze-wing record it is noted that the male once relieved at 6^h 30^m a. m., shortly after lighting the gas during an early-morning inspection. It is stated that this very early relief was probably due to the light.

INITIATIVE IN INTERCHANGE.

In the majority of cases the records do not state which bird was responsible for the interchange at incubation. From the available records it may be stated that either bird may take the initiative in leaving the nest or in resuming nest duty. In the bronze-wing, both birds took the initiative in resuming incubation more frequently than in leaving the nest, while the reverse was true for a crested-blond-ring pair. In the latter pair the male showed more initiative, both in leaving and in taking the nest, while in the bronze-wing pair both birds initiated the changes a nearly equal number of times. The female often leaves the nest early in the morning, before the first relief, in order to defecate, but she returns to nest duty at once.

When a bird takes the initiative in resuming nest duty, the mate often exhibits some stubbornness in giving up the nest upon demand. The female exhibits the most stubbornness and reluctance in leaving. Often the male is forced to give up the attempt to take the nest, and he is sometimes forced to crowd in and push her off the nest. In one case the female resisted for 15 minutes before leaving.

When one bird leaves, this departure is the signal for the other bird to take the nest, and as a rule this is done immediately. Sometimes one bird refuses to go to the nest when the mate leaves it, and the latter is then forced to return; otherwise the eggs are left uncovered until the first bird awakens to its responsibility. These periods in which the eggs are left uncovered vary from 1 to 6 minutes and they usually occur in the early part of the incubation period. The female was responsible for this lack of care in the majority of cases. While on the nest either bird may give the nest-call as a call for relief, and this call is sometimes heeded and sometimes not.

When one bird takes the initiative, either in leaving or taking the nest, this act serves as a stimulus to its mate. Under the caption "Incubation left to young," an instance is given in which a young bird goes to the nest, and this serves as the stimulus for the old bird to resign. During the early stages of an incubation period a pair of doves may be still feeding the young of the former cycle. The title of this note might indicate that the young bird's action in going to the nest is to be interpreted as an attempt to participate in the incubation. Such an interpretation is hardly necessary.¹ The note contains a seeming discrepancy of statement.

A pair of wood-pigeons have young able to fly and feed, but they are still fed by the parents. One young is in the nest-box and both old birds are on the perch [? a mis-statement.—EDITOR]. The young goes into the nest to sit beside the old bird, and the old bird resigns as she would for her mate. I drove the young off the nest and the old bird went back to duty. I have seen this behavior in the case of ring-doves and in some other species. (R 18.)

DEFECTIVE ALTERNATION.

A Japanese turtle female, mated to a homer, deserted her eggs 5 days after the first egg was laid. I had already transferred them to another pair and put other eggs in their place. The male homer has continued up to the present (for 5 days) faithful to his own duty, incubating during the day, and has tried to fulfil the duty of his mate besides. He has sat *every night* so far, while she has done nothing since her desertion. It is really remarkable that a male dove should undertake double duty. This is not the normal course of incubation, and one would not expect pure instinct to provide in one sex against the abnormal in the other. When instinct once ceases to acknowledge eggs, nothing can induce the bird to pay them any attention. Why is it that a faithful bird, accustomed to only regular hours of day, feels impelled to take the nest even at night when its mate deserts it? Is the sitting instinct continuous, and is the usual exchange regulated only by a regular round of needs? That is, does the female leave her eggs in the morning because her mate comes to relieve her, and would his leaving the nest call her back to it? This is certainly true in many cases. The male continues to sit at nights as well as during the day for 4 more days, at which time the female laid again in another nest. (BB 5.)

A male will often sit on the eggs at night in case the female deserts or dies; he will also sit overnight on the young as well as on eggs. An example of the latter behavior has just occurred where a male ring-dove is sitting at night on young only a few days old. (R 7.)

In the bronze-wing record the editor finds several cases of defective behavior on the part of the male. He fails to cover or feed the young during the day. He

¹ A case, however, is elsewhere (Chapter IX) reported by Dr. Riddle, in which a young bird—38 days old—nested eggs, and engaged in sexual billing with its two male foster-parents.—EDITOR.

roosts near the female on the nest at night, fondles her head when she is on the nest, follows her to the floor, and attempts copulation, etc. The female is thus forced to do double duty. In this connection an instance is noted in which "the female is absolutely faithful and sticks to the nest, doing double duty, while the male loafes about, occasionally visiting his mate and fondling her head without showing a particle of interest in the little one."

In a fourth case the incubation was normal from February 28 to March 15, shortly before the eggs were due to hatch. The male then began to sit irregularly and attempted to entice the female to begin a new cycle. To prevent this the male was removed from the cage early on the morning of March 16. After being on the nest all night, the female remained on the nest all of the following day and during the next night, a period of about 40 hours. On the morning of the 17th, the day the first egg was due to hatch, she left the nest and refused to sit another moment.

The female does not always do double duty when her mate fails to do his duty. There would seem to be a limit to endurance. In the first cycle of a crested-ring-dove pair whose record is given in Chapter VII, no eggs were laid. The female persisted in incubating an empty nest for 20 days, while the male did not participate. In this record it is noted that "she takes the nest at about the same time that she would if she were alternating with the male." The same conditions probably obtained in the second cycle of the same pair, and in two cycles of a similar crested-blond-ring pair; while no definite statements are made, the fact is emphasized that the female persisted in sitting at night. Sitting at night and indifference to the male are regarded as the proofs of the contention that the female was really going through the incubation stage of the cycle.

In the hybrid-*Zenaidura* pair whose record is given in Chapters I and VII, the male courted unsuccessfully for a month and then began incubation alone, without eggs, and on the floor of the cage. The records state that "this male sat steadily night and day" for a period of nearly 2 weeks.¹

COPULATION.

Copulation persists practically up until the first egg is dropped and it then, or very soon after, ceases. Normally there is no courting or copulation during the incubation period. When such activities are manifested by one bird, it is a sign that it is attempting to renew the cycle. If both birds participate, a new cycle begins at once and the eggs are deserted (see Chapter VII). However, one copulation was recorded on the seventh day of the incubation period of one pair and no disturbance of their incubation activities resulted.

NEST-BUILDING.

The nest-building which occurs during the mating period ceases during the egg-laying period, but is resumed as soon as alternation of sitting begins. The "free" bird spends much time in carrying straws to its sitting mate. At first the

¹ Some males are so hyperdeveloped in the tendency to sit that they hardly give the females a chance. (Conv. W. C.)

activity occurs very persistently throughout the day, but it soon becomes mainly confined to the early-morning period between 8 and 10 o'clock. This activity persisted for 8 days in the bronze-wing and then stopped. Both birds participated for the first 5 days, but the male alone was active thereafter.

NEATNESS IN NEST.

When the young hatch, the old ones—I saw the male do this once—take the shells in their beaks and carry them off to the farther corner of the yard and drop them. This is done to save the young from being cut or incommoded.

When roosting, doves defecate quite frequently, but when incubating the female allows nothing to pass the cloaca during the night, waiting until the male comes to take his turn in the morning; then flying to a remote part of the yard, she relieves herself of a monstrous load—often enough to fill a good sized spoon. The weight in one case taken at random was 11.75 g. A ring-dove laid her first egg at the usual time and came off the nest at 10 o'clock in the evening to defecate and then returned. In the morning, before it was fairly light, she came off again to relieve herself; it was evident that she felt the strain. She soon returned to the nest.

I have noticed that the male is also equally careful to attend to this matter only after leaving the nest. He does not, however, have to carry so large a mass, as he is not so long on the nest at one time.

The young, when defecating, reach back just as far towards the edge of the nest as they possibly can, thus keeping the center of the nest perfectly clean. The young, after they get to be a week or more old, push back as far out of the nest as possible. Before this age, the young reach back less, but the anus is protruded like a tube and thrust down into the bed of the nest so far that none is seen on the surface. I have often wondered how the nest was kept so clean during the first week until I noticed this habit. This habit is perhaps correlated with the habit, in the old birds, of adding new straw to their nest after the young are a few days old.

I learned that the female of a pair of archangels, unlike any other dove I have had, piles up her dung around the nest. As it is now cold weather, this does not matter so much, but I presume she would do the same in warm weather, when it might make a most filthy place of the nest. This seems to be a case where an instinct of a very fixed character has weakened and become obsolete.

One day, at 7^h 45^m a. m., I saw the male bronze-wing take the emptied shell of the just-hatched egg to the floor. On the next day it was noted that one of the young was dead and that the female had just taken it out of the nest and dropped it on the floor, where she had deposited the second egg shell. The young of a pair of mourning-doves was dragged out of the nest with the egg-shell and got cold before being discovered; the bird revived, but died on the same day. (R33, Em 7.)

The following similar incidents are reported by Dr. Riddle:

"Two *alba-orientalis* hybrids had been given eggs to hatch. In hatching, a small piece of the shell became attached to an umbilicus. Two hours later both bird and attached shell were found on the floor of the cage. While the act was not observed, there is reason to believe that the old birds, in attempting to remove the shell from the nest, had carried away the young as well. In another case, when one young had been hatched, the other egg was just nicely 'pipped.' In removing the shells of the first egg, the parents also removed, and deposited on the floor, the egg which was partly hatched. This egg was discovered shortly afterwards and the young was saved."

INFLUENCE OF TEMPERATURE.

A pair of blond and white ring-doves hatched a pair of eggs on January 19 and 20 in the aviary behind the house. The egg-shells were not removed from the nest on January 23, when I found the birds and removed the shells myself. I have never known doves to neglect this point during summer, nor in winter if they are kept in a warm room. Evidently the bitter cold weather of the week of hatching must have been the condition that prevented action. In the previous set the sitting was very irregular, owing to the cold, and the male neglected his duty altogether on the colder days. That a low temperature suspends breeding in *Ectopistes* and retards the process of breeding in all species is well known. The secretion of pigeon's "milk" is also checked by cold. (R 17.)

HIDING ON THE NEST.

A male mourning-dove from California is now sitting in the first pen on the west side of the house. The eggs were laid by a white ring-dove, 1 and 3 days ago. This is the "tamest" of all my mourning-doves. He always flies straight to me and alights on my hand or head or shoulders quite fearlessly. If I clasp him in my hand to carry him from one place to another, he makes no struggle beyond trying to keep his equilibrium. To-day I was astonished as I walked past his pen to see him exhibit the "instinct of hiding." He sat on the eggs (this is the first time that he has taken part in sitting) facing the front side of the pen. As I approached he drew down his head, closed his feathers, raised the wing next to me, and as I passed by to the other side the other wing was raised. I passed back and forth several times in order to see him perform. He kept up the hiding, and raised first one wing then the other as I went from side to side. The wing is raised without being opened at all. The shoulder is thrown up a little above the level of the head, so as to alter the figure and thus lessen the chances of discovery. The habit of lowering the head as far as possible is common in the crested pigeon and the common dove.

I brought in a young white-faced pigeon of 18 days to put a ring on its leg, and while I prepared the ring I left the bird in a cage near by. It soon took the characteristic "hiding attitude," resting on its breast with tail up, and held its head low and still. There it sat without moving, except for a slight breathing movement, for nearly 10 minutes, and would probably have sat there for an hour had I remained and left it to act its way. (R 17, Sh 8/13.)

VOICE.

NEST-CALL.

The nest-call is given frequently by both birds throughout the incubation period. It is almost invariably given upon taking the nest; it is sometimes given as a signal for relief, and frequently no purpose is apparent. These statements are evident from the following excerpts taken from the record of the bronze-wing pigeons:

The male gave the usual nest-call as he took his place over the egg. The female gave two to three calls as she placed herself over the egg. She gave the call three times while she was taking her place on the nest. The female is thinking of returning to the nest, and the male has called once for her. The male gave two calls a moment or two after resuming nest duty. The female went to the perch beside the nest and called twice, at which the male came off. The male had just settled on the eggs when he gave several calls. The male took his place and gave one nest-call. The male gave a call before leaving the nest, and I think this call was for the female to relieve him; he seems hungry. The female gives the nest-call, or a call very similar to it, just before she takes her position to drop the second egg. Hence this is not a call for hay, but perhaps a call that means, "I am in the nest, don't disturb me." Other species also do this; at least some others do.

The nest-call is also used in connection with egg-laying and the feeding of young. The crested pigeon gave the call-note almost continuously just before laying. A mourning-dove likewise gave a low call several times just before she took a position to lay. The call here was the *usual call to nest-making*. The feeding-call, which is given by adults during the act of feeding the young, is essentially the same as the nest-call for straw. (R 19, R 28.)

During a period of 165 minutes that a male bronze-wing was on the nest there were recorded 55 nest-calls on the part of the male to 7 for the female. During 39 minutes in the afternoon, while the male was on the nest, 17 calls were noted for the male and 1 for the female. During 55 minutes while the female was on the nest, the male called 12 times and the female 8 times. During incubation the male thus seems to call more frequently than the female. Probably calls are more frequent while the bird is on the nest. Either bird may take the initiative in calling and usually the calls are not answered by the mate.

ALIGHTING, OR SHORT-NOTE CALL.

The short-note call is a regular thing on landing, whether on the perch or on the floor, for both sexes of bronze-wings. The above generalization is amply supported by many notes in the record of the bronze-wings, a few examples of which are given:

The male went to perch near the nest and emitted three or four short notes; these were rolled off quickly without other demonstration. Then he returned to the floor and repeated these peculiar quick, sheep-like notes and began looking for straws. The female flew to the floor and immediately on alighting gave the short quick notes—four to six—uttered about as rapidly as possible without blending. The male returned to the nest and gave the short notes upon arrival at the perch. The male flew to the perch in front of the nest and gave the short-note call—two short grunts. The alighting-note of these birds is a short note repeated rapidly. This is homologous with the threatening note of the white-wing (*M. leucoptera*) and other species. (R 33, R 1.)

CHAPTER VI.

FEEDING AND CARE OF THE YOUNG.

During the first week after the hatching of the eggs the old birds continue their alternation of nest duty. At the end of this time the young can be left uncovered for some time without harm, and the period of "close sitting" characteristic of the incubation period ceases. At the end of the second week the young begin to venture from the nest and become more and more independent of parental care. The young are fed by regurgitation. The food at first consists of "pigeon's milk," a secretion whose appearance is well timed with the end of the incubation period. Later the young are given the partially digested food of the parents. While in the nest (2 weeks) the young rely entirely upon this food. After leaving the nest they begin to pick up food of their own accord, and they can be "weaned" at the end of 4 to 5 weeks. Both parents participate in this feeding for the first two weeks, and in case they do not begin a new cycle, both may continue the feeding for some time later.

With a renewal of the reproductive cycle, the order of events is changed. The cycle may be started at the end of the first week, when close sitting ceases. The female is then ready to lay at the end of the second week, just as the young are venturing from the nest. The female then stops feeding and devotes her entire energy to the task of incubation. The male continues the feeding and also participates in the incubation of the second set of eggs. When the eggs are hatched, the male devotes his attention to the new set of young, and the first set are forced to rely upon themselves for their sustenance. "Driving" is sometimes necessary to accomplish this weaning of the first young. If a series of cycles follow each other in immediate succession, the male bird will thus be continuously engaged in the task of feeding his various broods of offspring.

GENERAL NATURE OF THE ACTIVITIES.

At the end of the period of incubation (2 weeks) and a further week or more in care of the young, the pair renew the cycle of events. The young are fed by both parents until the female is about ready to lay again, then the male continues the work alone and the young begin to help themselves. As soon as the time of hatching arrives, the previous young begin to learn that they are no longer wanted and, if they do not leave, the male takes them in hand and drives them without mercy. All this is to the end that the newcomers may be safe in their nest from attacks by their elder brother and sister when the parents are away. The bird has no idea of what its actions mean, for its actions are according to "feelings" which follow each other in regular serial order, making the same round each time. The close sitting normally lasts for about 21 days—two weeks to hatch and one week on the young.

A pair of bronze-wings were brought into my library, about the middle of November, in order to save the young, then about 4 weeks old. The young and old had done well, although the young have not developed flying power as they would if they had lived

outside in viable conditions. The old birds kept on feeding the young until about Dec. 7, or between 7 and 8 weeks.¹

I notice that a pair of young mourning-doves, 1 and 2 days old, are sleeping quite uncovered in front of the male. The young birds are in the nest, and the parent bird seems to have drawn back a little to one side of the nest so that the young can sit uncovered. The heat is oppressive for the first time this season, and the birds are left uncovered because they are more comfortable so. In cold weather this would not happen.

When a nest-box with young is placed on the floor of the pen, the young will usually begin to get up on the edge of the box a few days before they are 2 weeks old. At 2 weeks they will often venture to jump from the box to the floor of the pen, a height of 3 to 4 inches. A pair of blond ring-doves got out of the box 2 days before they were 2 weeks old. The young are unable to fly at 2 weeks and these young were plainly prematurely out of the nest. Similarly a young hybrid from a white fantail and a ring-dove, at just 2 weeks old—a full week before it would venture to fly from its nest—stepped out of the nest-box, which was kept on the floor, on to the floor of the pen, and walked around with the foster-parents, which were eating their breakfast. The young bird then, without experience, appreciates the conditions which make it safe or unsafe to leave the nest. If the nest were several feet above the floor it would not have ventured out for at least a week.

At two weeks of age, and the first or second day after they get out of the nest, the young quite generally learn to pick up seed and bread crumbs, if these are placed near them; but they are almost invariably, if not always, led to do this by seeing the parents eat. The parental example is the guiding stimulus.

A female passenger-pigeon left her young early in the morning at the age of about 8 days, and neither parent covered the young during the day, although the mother continued to cover the bird for two nights more. Two days later the parent birds began a new cycle. The young of this second cycle were left uncovered when 9 days old. When their young were only a week old, a pair of fantails ceased to sit continuously and started a new cycle. Sitting continued intermittently until 3 days later, when the female took the perch at night, leaving the young uncovered. Both birds of a pair of mourning-doves came off the nest during the daytime, leaving the young alone at the ages of 6 and 8 days. Five days later the female left the young at night also and sat on the perch with the male. They were thus left uncovered before they were quite 2 weeks old.

A pair of white-face pigeons (*Leucosarcia picata*) gave, in contrast with the above cases, remarkable and unceasing care to a young bird hatched by them. One or the other of the parents remained every minute with the young until it was 19 days old; this youngster, moreover, was kept "covered" during the whole time, except for a short time towards the last, when it sometimes sat beside the parent rather than under it. I have never known any other pigeons to keep close to the nest after the young got to be 10 or 12 days old; frequently the old birds begin to leave the nest a little at the end of 6 or 7 days. A new egg was laid 2 days later, but it did not develop. Evidently the close care of the young did not give the male a fair chance to fertilize this egg. One such young of this species, when 6 days old, was put in a cage with the parents and taken on a railway journey of nearly 1,000 miles. The old birds took care of it on the way, covering it as usual. On arrival, I left the young and old in the cage over-night. On the next day I moved them to a new pen, placing the nest-box with the young in it on a shelf. In this new position the old birds did not seem to feed it and refused to cover it.

¹ This pair did not renew the cycle immediately, and this may partly account for the long period of feeding. A new cycle was started on Dec. 10.—EDITOR.

The following incident was observed in November, in a pair of young common pigeons that were hatched on Oct. 26 and 27. These birds were about $3\frac{1}{2}$ weeks old, not ready to fly. The old birds wanted the nest for a new set of eggs and began to drive the young. These, wonderful to say, bore it for a while and then began to resist, and fought with such desperation that the old ones left them in peace. I saw this fight repeated several times.

After feeding, the young usually turn so as to sit with the head pointing backward under the parent. This position is the one almost invariably taken by the passenger, ring-dove, crested pigeon, and the domestic dove.¹ (R 17, R 33, R 6, R 7, R 19, C 7/33, Em 7, Sh 8/13.)

FEEDING OF YOUNG.

Most people know something of the way the pigeon feeds its young. There are, however, some rather extraordinary things that happen in connection with feeding that deserve mention. Suppose we place the young of a small species under the care of a larger species—a young ring-dove, for example, under a common pigeon or homer. The old birds will take care of this young ring-dove just as faithfully as they would take care of their own young. But when this young bird gets out of the nest, at a week or 10 days, he is not able to take all the food that the old birds want to get rid of; the homer can not feed this young and small bird as much as he desires to feed it, and we can imagine that this gives the homer a quite unpleasant feeling, for he behaves in a way to indicate this. When the young bird does not accept all the food that is offered to him, then the foster-parent begins to tease the young to accept it. The parent will pull the feathers of the young very gently and bite its beak, or give it a gentle pinch, just to stimulate it to feed. The little bird will respond to these things until it has so much that it can hold no more; but the old bird urges it to accept still more. Finally the parent begins to pinch the young bird's beak a little more severely, and to pull its feathers a little more strongly, and—being a larger species—behaves in a way rather rough for the smaller species, and in the end alarms the young bird, which now tries to get out of the way. The old bird follows it up—he can not give up, but is fully determined to get rid of all his food. Naturally it troubles and startles the young bird to be pursued in this rough way and the old bird sooner or later gets angry and begins to peck the squealing, retreating young very severely, sometimes pulls out its feathers, sometimes pulls off the skin of its head, neck, and back, and if the young bird is not taken away it is very often killed.

Now, I am perfectly certain that the old bird behaves in this way, not from any malicious motives, but just for its normal relief. There are a great many ways of becoming sure of this fact. This behavior, of course, is found in birds of different species. I have tried some of them in many different ways and found this view of the behavior confirmed by other behavior which is analogous. In further illustrations of this, we may consider a situation which is sometimes met with in the case of a common pigeon and her own young. When one of the two young of a brood is hatched a little too long after the first one, the first hatched is apt to get quite an extra start in growth and be much stronger than the second one; when the second one is hatched, it is fed a "little" and the other one is fed "more," and so from day to day the first one continues to outgrow the second one to such an extent that the second one has not the strength or ability to stand up and get as much of the food as the first one; so the difference increases from day to day. The second bird is more and more hungry, because the old bird is satisfied with the vigorous bearing and

¹ When the bird is sitting the eggs are usually placed end to end in the median line. They are usually too far back under the abdomen to come into uncomfortable contact with the keel of the breast bone. The young commonly face toward the tail of the sitting parent. It seems as if they can be better covered by the feathers in this position. The parent easily turns round to feed the young. (Conv. 8/6/08, W. C.)

desire and energy on the part of the stronger bird. The second one does not satisfy the old bird and is more and more neglected and in the end it becomes a dwarf bird, or it may die.

On the question as to the part played by intelligence in these cases, I may say that it does not seem to me that the birds exercise intelligence; they simply act in accord with their feelings. They appear to be very fond of the young birds, but their fondness for the young is all determined by their feelings, or desire for relief. The moment they get over their desire to feed they also get over their fondness for the young. If the eggs do not hatch they have a desire to feed, but it is not so strong as to lead to bad results and they soon outgrow it; it does not then make them sick. In those cases, however, where parents really get started in feeding the young, the need to feed is most pressing; and if the young die in two or three days after hatching, then the old birds are not only frequently made sick as a result of not being able to feed, but frequently sick to death.

The special secretions in the pigeon's crop seems to be stimulated in part by the sight of the young and the amount of stimulation, or rather the amount of food which the parents want to relieve themselves of, and it rapidly increases in amount during the days which follow the beginning of feeding. If they do not begin actual feeding they get over it, but if they once get started it is necessary to go on; otherwise they suffer.

I have noticed in pigeons that the "weak are neglected" and the strong favored. This is seen in the feeding as noted above. To get the full benefit of the parent's ability to feed the young must *push, squeal, and flap its wings—and all this with vigor*. The moment these acts are not well performed, the parent's exertion dwindles for lack of stimulus.

The feeding process is performed—at least in many cases—purely *to get relief*. The old bird gives "milk," and at intervals this secretion must be thrown out. I have seen a parent try to induce young to feed when the latter had no desire, having been well filled by the other parent. The old bird gets into the nest and calls; if there is no response it takes hold of the beak of the young and begins to pump vigorously. If the young die, or if they are taken away, one may see after 6 to 10 hours how eager the parents are to relieve themselves of the food reserved for the young. They are ready to feed *anything* that will put its beak into their mouths; they will often return to weaned young (crested pigeons) and feed them for a second time. They will try to feed an adult bird if that bird's beak is only held in their mouth, and held low enough to simulate young in the nest.

On the other hand, the old birds will often try to feed when they have nothing to give, *e. g.*, when young are given to them before the regular time for hatching has come. Thus the act is performed sometimes for relief, sometimes in answer to the teasing of a hungry young.

The theory that the act was primarily one for relief from too much or from indigestible food, and secondarily turned to use in feeding, has one great difficulty, namely, to account for the "milk." I do not think that could have been at first a product of a useless nature, like ejected food. It is something that has probably been developed in conjunction with the feeding. The dove's method of feeding occurs also in some other birds.¹

As the young get larger, their feeding becomes for the parent more and more of a dread, as they are ravenous and push with all their strength to get the food. The old bird becomes wary and makes haste to finish quickly and retire, going out of the cot often before it has full relief. It then continues to call, but hesitates to go in. The young stand at the hole and squeal. The appearance is as if the old bird wanted to entice the young outside. Later the old one grows still more cautious and the young venture out and are fed. The next time they go out quicker and the old bird retreats. It then looks as if the old bird wanted to teach the young to fly. It is evident, however, that this is no thought-out art,

¹ Lucas states (*Mental Traits of the Pribilof Fur Seal*, V, 1899), that the young of the fur seal was fed by the mother for her own relief.

but an art that grows out of the situation—young clamoring for food, old ones anxious to relieve themselves, and fear of the push of the young.

The old bird normally feeds two birds at the same time, and it seems to need the two-sided contact to get full relief.¹ If there is only one young, the old bird after feeding from one side may walk off to the other side of the nest and thus give a chance for a change in position. (SS 10, R 24, B 2b, R 7.)

This "feeding from both sides" has been mentioned in a previous topic (Billing and feeding in uniting, Chapter II), under which are described a few cases in which the male was observed to "feed" the female. This sort of "feeding" is, however, connected with the sexual billing which precedes a copulation. But the close similarity of the activities in the two kinds of "feeding" is certainly remarkable; for it is stated that "the male feeds the female with the same up-and-down shake of head and crop as is used with the young, and then she shifts to the other side," and also that the male opens his beak and the female inserts hers first on one side and then on the other.²

Fulton, on page 42 of the work already cited, states:

"The pigeon's 'milk,' which has pointed so many a joke, is no myth, but a veritable existence; the fact being that as the time for hatching approaches the crops of both old birds secrete a soft substance closely resembling curd, which forms the solid food of the young pigeons for some days, after which its quantity slowly diminishes, and it becomes gradually mixed with the grain more or less softened, till by degrees the young pigeon is thus introduced to hard food and can feed itself. This 'soft food,' as it is called, is pumped up by the old ones with a sort of vomiting action, and the little pigeons have just sufficient sense to feel about for the bills of the old birds, into which they insert their own, and are thus fed; they will feel in the same way for the finger if held to them. It is singular, but true, that the beak of a young pigeon, being thus almost entirely intended for a kind of suction, is much *thicker and larger* in proportion to the body than in after life, besides being of a soft and fleshy character. It looks immense at first in proportion to the bird, but gradually shrinks and hardens."

ANOMALOUS FEEDING BEHAVIOR.

Two young hybrids, one white (*H*) and the other blond (*J*), were with their foster-parents in a cage. The old birds were at the time out of the nest. The white young (*H*) appealed to *J* for food, whereupon the latter several times opened his beak to receive that of his nest-mate, and shook his crop and wings as if it would give up food. Soon the white young actually inserted its beak into that of *J* and the latter fed it in a vigorous manner, pumping up food liberally until I interrupted, thinking it could not be well for *J* to part with its food. *J* is only 12 days old, and it is at least 3 days behind its companion in the development of its feathers. It was a strange sight to see this unfledged bird, with only pin-feathers on its head, and much of its body bare, feeding another bird more advanced in its feathers, although of about the same age and weight. I have never before seen or heard of such a performance.

I have seen both young and old throw up food that was indigestible, especially when sick. I have seen them in good health overeat and cram themselves with more than could be readily swallowed, and then seek relief in throwing up. In so doing the movements may all be the same as in feeding the young—the head is held down, the beak open, the

¹ The parent takes care to feed both young. I am not sure that this is intentional, but it looks almost so. The parent feeds for a time, then stops, disengages, and moves around a short distance before commencing to feed again, so that it usually happens the other young gets the second feeding. (Conv. W. C.)

² This statement is made for the bronze-wing, which is a species that copulates on the ground. For those species which "bill" and copulate on a perch, or branch of a tree, the shifting of the billing from one side to the other would seem to be a rather difficult or awkward matter. Possibly, however, it occurs in these latter species also. It certainly sometimes occurs in the case of ring-doves when these birds copulate on the ground.—O. R.

crop is shaken, and with it the whole body, especially the wings. The power to regurgitate is, then, common to doves, old and young, and *it has come secondarily into service in the care of the young.*

What prompted *J* to feed its white companion? I think the crop was a little overloaded, and that, together with the stimulus of a teasing beak, led it to give up food. It was not, however, an act of vomiting merely; for *J* offered its open beak several times to the companion, and in a way that was unmistakable, so that I wondered at it before the feeding began. When the beak was inserted in the open beak the whole machinery of correlated movements was set in motion and the young bird behaved in all respects like an adult bird. The beak inserted in the throat may have much to do with stimulating the process.

A hybrid between a ring-dove and the European turtle was 11 days old; it had as a nest companion a ring-dove 1 week old. The ring was small and covered with pin-feathers; the hybrid had many wing-coverts and scapulars unfolding. These birds were under the care of a pair of ring-doves; both were perfectly healthful and strong. I noticed the young ring teasing the hybrid with its beak, as young birds scantily fed often do with a nest-mate. The vigorous billing about the hybrid's beak and neck led it to feel like feeding, and it opened its beak several times for the ring, and once after offering the open beak, it put its head down and shook its wings and crop as an old bird does in feeding. The young ring did not get its beak into that of hybrid, but came near doing so. (R 24.)

TRANSCERENCE OF YOUNG TO FOSTER PARENTS.

The young of any species may be transferred to foster-parents, provided they are put under the foster-parents at the time the eggs of the latter are due to hatch. It does not seem to make any difference whether the young birds are transferred when they are just hatched, or at a week or 2 weeks old, provided only that they are not old enough to stand up straight and raise the head too high. The old birds do object to taking care of any young birds that stand up and look too much like old birds. If the young simply sits down, holds its head down in the proper position for care, that is all that is required; the old birds will feed it just as well as if it were hatched out under them. If eggs are transferred one must always be sure that they are properly timed; that is, timed to hatch with the eggs which are removed; if they hatch too early, or are due to hatch too long after the time of the eggs removed, the transfer is not successful. The foster-parents are as well satisfied with the eggs of other species as with their own; they do not know the difference.

The necessity of exactly matching the time of hatching of the transferred eggs with that of the eggs removed is one of the complications that is met with in attempts, such as my own, to obtain and hatch unusually large numbers of eggs from particular pairs of birds. I have had some trouble of this sort. The common pigeons, however, are a little less particular in the matter of the exact time the eggs are due to hatch than are the wild species. Also, in crossing common pigeons with the wild species one finds that the former will usually continue the incubation a few days after their mate's usual time. The wild passenger-pigeon never waits more than 10 or 12 hours. If the egg does not hatch within that time he leaves it; even if the shell is broken and the bird is nearly ready to hatch it is deserted. If young are put into their nests before they are due to hatch they are not able to feed them; much care in this matter is necessary. "Pigeon milk," as it is called, seems to be ready at the proper moment. Everything is well-timed, and if there are young birds in the nest before this time arrives they will get no food. (SS 10.)

Fulton, in pages 42-43 of the work previously cited, contributes the following on the subject under discussion:

"Hence the practice of employing 'feeders' or nurses, which are necessary to all fanciers of the 'high-class' varieties, and to which the young are transferred when a few days old to be reared, only being left long enough with their own parents to 'feed off the soft food,' which would otherwise make them sick and cause the hen to be much longer in laying again than if allowed to feed young for a few days. The young require to be left with the old birds, in general from 6 to 8 days, in order to relieve them of their soft food, when they should be shifted to the feeders. But in shifting, one caution is very necessary, viz, not to shift to old birds which have hatched *before* the young ones it is desired to rear. Should this be done, the young will in all probability perish, through the food now supplied being too 'hard' or too far advanced for them, in conformity with what we have already explained as to the gradual change in its character, by increasing mixture with grain, which the young can not digest till the proper age. On the contrary, should the feeders have hatched three or four days *after* the breeding-birds it will be all the better, and do the young a great deal of good, since nothing brings on a young pigeon so well as this extra allowance of soft food."

"Another caution may be necessary. We have seen how easily, in the case of most pigeons, the young may be 'shifted' at almost any time desired within a fortnight; and pigeons will also take to and sit upon other eggs than their own; but it will *not* answer to give to any pair eggs partly hatched, unless laid at the same time as their own, and therefore due to hatch at the same date. The reason is obvious; the eggs hatching before the ordinary time of incubation is expired, there is *no soft food* ready for the young, and they must therefore perish. One day or perhaps two does not matter; but success when the shifted eggs have been sat upon more than this is very doubtful."

VOICE.

FOOD-CALL OF YOUNG.

The call for food in the bronze-wing is a cry resembling that of young pigeons in general—a sort of mild whistle given in a beseeching manner, from a fraction of a second to a second and a half long, and varying in loudness and shrillness according to the eagerness for food. In general, the manner is very deliberate and free from the excitement and hurry shown by common pigeons. If the young does not get the attention of the old bird, it may stop in front of the parent and give a few of the polite bows so characteristic of the old bird. The young bows with the same motion as the adult, and quite or nearly to the floor. It is a comical thing to see this bow from a bird only 2 weeks old, and before it has had any opportunity to learn from the parents. The call is repeated at varying intervals and is often continued for some minutes.

As just noted above, the call of the young for food is very calmly delivered, but with earnestness, and no flurry or scramble as in common pigeons. If the old bird, after giving the young a taste, walks off, the latter looks earnestly for more, but does not rush and flap its wings against the old bird; it moves towards the old bird with a slow, hesitating step, lifting its wings only a little and wagging them slowly up and down as if pleading, and it again gives the beseeching whistle as it approaches.

When the old bird first approaches the young to feed them, these welcome him with their affectionate and pleasing little twitter—the "whistle" broken into a ripple of few or many sounds; these are generally low, but the same sound may be quite loud. A good demonstration of this loud whistle was obtained in the following instance. A young bronze-wing escaped, but came back and alighted on the top of its old pen. Here it sat looking down at its mate and the old bird, whistling loud to get back. The whistle was delivered with the beak quite wide open, and sometimes it was broken into a twitter, the whole frame seeming to shake at the sound. The voice of the young reminds one of the voice of the sandpiper. The wing-movements of the young, when appealing to the old birds for more food, are the same as those given in conjunction with the nest-call by the adult male.

FOOD-CALL OF ADULT BRONZE-WING.

A female bronze-wing came several times to the near (feeding) side of her cage, at about 3 p. m., and gave a peculiar little grunt of impatience for lack of food. This was about the time for her to return to the nest for the night, and there was no seed in her dish; she

was anxious to eat before returning, and hence expressed her want in the short guttural oo sound. This sound was made with the mouth closed, and was repeated rather quickly several times as she stood looking expectantly for me to give her food. As soon as I did so she fed and I heard no more from her. I heard the same sound, only stronger, from a bronze-wing kept in the basement of my home, and on looking I found the bird had neither water nor seed.

The female referred to above called again for food 6 days later, and came to the side of the cage nearest me and tried to get through. I then learned that she repeats the call at a rate of two to three notes a second, and sometimes she brings her effort to an end with several notes cut short and run off close together as rapidly as the tip of the tongue vibrates in giving the sound of *r*. Thirteen days still later I saw this female go to her nest and use this same call to her mate to leave the nest; she then "wanted to feed the young."

FEEDING-CALL OF BRONZE-WING.

A female bronze-wing was heard calling, and at the same time it was noted that her young also were calling for food. Glancing at them, I found that the old bird's note was given as the young reached up towards her beak to be fed. She repeated the call several times before taking the beak of the young. The note was essentially the same as the nest-call for straw. A week later at 9 a. m., I saw the female feeding her young. With every shake she gave the usual call, but it was *very low*, as if half-suppressed and it was given without dropping the beak of the young; *i.e.*, the calling was continued *while* feeding, only very *quietly*. In ring-doves and other species I have heard feeding-calls given while in the act of feeding, and have observed that this is often an expression of the "satisfaction of the old bird in the process."

RESISTANCE TO INTRUDERS.¹

A detailed record, made on two different days, of the behavior of the bronze-wing in resisting a hand directed toward the incubating bird, is given herewith: (1) I move my hand slowly towards the bird, on a level with the top of the nest-box—never above the bird, as that alarms her too much. As the hand comes within a few inches of the nest-box, she places herself sidewise or at right angles to the line of approach, gives a growl, and raises her wings straight up, prepared to strike if approached more closely. By moving the hand very slowly, and taking care to move steadily, without jerks, she may permit me to get my hand within 3 or 4 inches of the eggs, but she is afraid and retreats enough to allow a sight of one or both eggs. Usually, however, she strikes several times sharply if the hand comes within an inch of the eggs. In all this she is in a threatening attitude, with wing ready to deliver a quick blow, and she growls more often and viciously the nearer you get to her. Between growls she "puffs" like a young dove that is old enough to be frightened when approached. She may permit you to touch the eggs without being frightened off, but she protests with vigorous growls and blows from the wing. (2) As I approach the female with my hand, she is careful when she strikes with her wing not to stir her feet and thus endanger the young resting between her legs. Her growl is a rough rumbling, guttural sound, in making which the bird opens its beak but slightly and raises both wings over its back; the feathers of the back, including the upper tail-coverts, are raised, reminding one of the way a dog "bristles." The tail also is more or less spread and held horizontally, or raised very slightly and rigidly.

A "growl of warning" is given by the bronze-wings when the bird is nesting eggs, and the same note is still more strongly given after the eggs are hatched. The note of threat is a growl, or better, a grunt, expressing fear and a disposition to resist intrusion to the nest. It is made when one puts his hand near the nest.

¹ See topic on "Periodicity of Disposition to Fight," Chapter I.—EDRION.

NOTE OF ALARM¹ OF BRONZE-WING.

A male bronze-wing that was sitting on the nest, over the 1-day-old young, saw a cat run along the sidewalk; the bird stretched his neck at full length, nearly vertically, and held his head a little aslant, with one eye fixed steadfastly on the cat. The female was on the floor and unable to see the cat. The male gave a very low short muffled note of "anxiety" or "alarm." The female was at once alert, with feathers held tightly, as if danger was expected. The note is not only low and short, but quite smooth, no vibration being noticeable. *Geopelia humeralis* gives a similar note on like occasions, but it is not quite smooth, is just a little hoarse, though not loud. The note is uttered by a short, quick expulsion of air with the "beak closed." All species seem to understand this alarm-note, no matter which species gives it.

FLOCK WHISTLE OF YOUNG BRONZE-WING.

The young bronze-wing has another note—a soft, pleasant twitter—that is hard to describe. It almost continuously gives this note when it is on the ground, and I incline to think that it facilitates the movements of the family and enables them to keep together. These birds spend all their time running about on the ground, and some such note would enable the old birds to keep track of the young. This mellow whistle of the young reminds one of the notes emitted by the Bartramian sandpiper (*Bartramia longicauda*). Chapman describes, in his *Birds of Eastern North America* (p. 168), this sandpiper's note, when flushed, as "a soft bubbling whistle." (R 28, R 33.)

¹ Descriptive material may be found in Chapter X.

CHAPTER VII.

DEFECTIVE CYCLES.

The reproductive cycle consists of numerous activities which, when normally related to each other in a definite temporal order, are nicely adapted to achieve that essential result—the production and rearing of young. While harmony and adaptation are the rule, yet certain faults, defects, and abnormalities, serious and trivial, frequently occur. In the normal series of events it is evident that these activities must stand in some sort of a mutual relation of cause and effect. To the analysis of this causal interdependence the normal series of events can furnish but little help. The key to this analysis lies here as everywhere in experimental control and alteration of the order of events. The defects and abnormalities which are described in this chapter possess not only an interest *per se*, but they may be regarded as isolated bits of nature's own experimentation which may furnish some help towards the proper analysis of that complex organization of activities constituting the reproductive cycle. For the most part, these accounts consist of excerpts and digests from the various records which present the essential facts pertinent to our purpose.

BRONZE-WING.

FIRST CYCLE.

The eggs were laid on December 16 and 18, 1905. The incubation record was normal up to December 17. The eggs were hatched on January 3 and 4. During the last week of the incubation period the male participated fairly well in his incubation duties, but deviated from normal behavior by attempting to entice his mate to desert the eggs and start a new cycle. After hatching, the male refused to cover or feed the young properly and consequently both died within a few days. A new cycle was started immediately afterwards.

The male thus discontinued his cycle of activities, without any apparent external cause, 15 days before its natural end. The female continued her cycle for 11 days, or until the death of the second young on January 7, in spite of a number of disturbing factors. These were, (a) the necessity of doing extra duty in the care of the young, (b) the continual solicitations of the male, and (c) the death of one young. With the death of the second young, the normal sequence of activities was interrupted 4 days before its normal completion and a new cycle was started.

The above facts are verified, and the necessary details supplied, by the following excerpts from the daily incubation records:

Dec. 27.—At 3^h 45^m p. m. the male calls again five times and the female answers once. The male this time does not attend to the call of his mate, but walks back and forth on the side of the cage. His many calls evidently indicate that he has a sexual inclination. At 4^h 44^m p. m. the male walks nearer to the female, getting onto the edge of the nest, but she sticks to the nest and gives a low call as much as to say: "I must be left alone." At 5^h 46^m p. m.¹ the male is again on the edge of the nest and the female protests by two more

¹ This is the normal time for the male to be on the perch for the night.—EDITOR.

calls, and he again retires to the opposite end of the perch. It is now after sunset, getting dark; but I have the room lighted, and this perhaps incites the irregular behavior in the male, for he is already back to the nest again at 5^h 48^m. Two or three times more, between 5^h 30^m and 5^h 55^m, the male returned to the nest after I had lowered the light; the female protested every time and he called as if uneasy at something. At 6^h 30^m I find, on going to the room, which has been dark since I left and locked so that no outside disturbance could occur, that the male is sitting on the perch close in front of the nest instead of at the most distant end of the perch, as I should expect.

Dec. 29.—At 7^h 34^m a. m. the male is on the side of the nest, calls twice, waits a moment or two, walks off the perch, and is now walking uneasily back and forth, as if he would like to get out of the window. The same behavior was noticed for the last two or three days.

Dec. 30.—The male is standing in the nest beside the female, fondling her head. I presume he wants to relieve her again.

Dec. 31.—After keeping the room locked from 1^h 46^m p. m., I returned at 6 p. m. and found the male sitting on the perch directly in front of the female, instead of sitting at the distant end of the perch.

Jan. 2.—At 7^h 35^m a. m., the male went to the nest and fondled the head of his mate while standing on the side of the nest. He then pushed the female off the nest, but refused to sit. At 10 a. m. the first egg is hatching. The female has been off the nest for 30 minutes, and meanwhile the male has not offered to sit. In fact, he has stood for 20 minutes on the nest without sitting, and he walked to the perch just before the female stepped to the nest. The male is ready to renew the nesting cycle. I noticed this as early as yesterday, but more plainly to-day. His way of going to the nest and fondling the head of the female as if she were not doing serious duty, sometimes carelessly walking over her, and also sitting near her at night, all indicate this fact. Besides, he sits very perfunctorily. To-day he left the egg and came down to his mate on the floor and began courtesying to her as if he desired to copulate.

Jan. 3.—The first young hatched this morning. The male went to the nest and fondled the head of the female, but did not relieve her till 1^h 05^m p. m. He gives no attention to the young bird and does not sit down to cover it. His behavior confirms the conclusion of yesterday that he prematurely arrived at the end of his incubating period and has now become totally indifferent at the very time when he should be most attentive. The female is absolutely faithful and sticks to the nest, doing double duty; the male meanwhile loafs about, visits the female, and fondles her head, but shows not a particle of interest in the little one.

Jan. 4.—The second egg has hatched. One young, probably the first one, is dead.

Jan. 5.—The male relieved the female several times during the day, but he does not really sit; he "stands" over the young or on the edge of the nest. He makes no attempt to feed the young. He bows to the female and solicits her frequently. He feeds the female once, tries to copulate with the seed-dish several times, and attempts to mount the female.

Jan. 7.—The male has refused to cover or feed the young. The second young bird is dead this morning, the female not being able to cover it continuously. The male has been trying to entice the female to a new nesting cycle. This new cycle started shortly after the death of the young bird. (R 33.)

SECOND CYCLE.

The first egg was laid on January 16, but it was thin-shelled and broken. The second egg was laid on January 18. The incubation record was normal for 5 days. The egg was then gradually deserted during a period of 3 days, and a new cycle began on the day following. The cycle was thus terminated 10 to 13 days before

its normal end. The only known external defect was the loss of one egg, but this factor had no appreciable effect upon the incubating impulse for at least 5 days. While the male led in the desertion, the female must have been similarly predisposed or she would not have responded so quickly to his sexual advances. The following excerpts from the records are apropos:

Jan. 23.—In the morning the male bowed in front of the female, very strongly striking the floor at each bow with his beak.

Jan. 24.—At 4 p. m., both birds were on the floor, hugging, mounting, and strutting, but without contact.

Jan. 25.—Before 11 a. m. both birds have been off the nest several times, and I have not seen the male sitting at all. They are interested in courting and copulating.

Jan. 26.—Hugging, bowing, and "feeding" of the female by the male without coitus occurred in the morning. The egg was finally deserted in the afternoon. Little attention was paid to the egg during the day, and when night came the female did not sit on the egg. Desertion has been gradual with the female. The male has led in the desertion; he enticed the female from her work. This behavior is similar to that observed earlier in the crested pigeons. These crested usually sat only a few days and then began over again. In one case the female laid four eggs with but little interruption between the sets. (R 33.)

THIRD CYCLE.

The incubation record was normal until after the death of the first young on Feb. 20. The egg was injured in handling on the 19th, and the bird died shortly after hatching on the 20th. The male's cycle terminated shortly after this event and he began soliciting the female to renew the cycle. The female resisted his advances until after the death of the second bird, which occurred during the night of the 21st. The birds began copulating on the morning of the following day. The termination of this cycle is evidently connected with the death of their young.

Feb. 21.—Yesterday, at the time the young was due to hatch, the male was very attentive and anxious to have the nest and care. Indeed, he appeared to be remarkably solicitous, and not only tried to get the nest, but called quite a number of times while sitting beside the female, as if he wanted her to get off, and as if he wanted to feed the young before it was quite out of the shell. This morning his behavior is already decidedly changed. He runs over the female and the nest carelessly, and when the female left the second egg for a few moments he at first charged at her, uttering his scolding notes, and then he mounted her twice and went through the routine, but without coitus. I believe that the male was so closely timed with the hatching period that the slip of yesterday (death of first bird) ended his course and that he is now ready to renew another course.

Feb. 22.—The fourth cycle began this morning immediately after the death of the second young. The birds were copulating right away, although no actual union took place at first.

FOURTH CYCLE.

The eggs were laid on February 28 and March 2. The male's behavior was slightly irregular from the first, though he participated in his incubation duties. With no apparent external cause, the male gradually terminated the cycle shortly before the eggs were due to hatch. His sexual advances finally broke up the cycle for the female.

Mar. 15.—Contrary to usual behavior, the male sat every night beside the female in the nest-box. To-day he tried to copulate with the female while she was sitting on the egg. He tried this also yesterday morning. The first egg is due to hatch 2 to 3 days hence. Probably the male will be unable to feed the young in case they hatch. The female is faithful.

Mar. 16.—The male was taken away because he had succeeded in getting the female weaned from the nest so that she would stay with him on the floor and copulate. After removing him the female sat one day and night; but on the next day, when the first egg was due to hatch, she refused to sit another moment. I shall keep this pair apart for a while to see if they will fall into regular work next time. (R 33.)

GEOPHELIA HUMERALIS.

The eggs of the first two cycles (of 1906) were thin-shelled and were broken within 2 days after the second eggs were dropped. The cycles were terminated immediately. In the first case, a renewal started immediately; but it was delayed several days in the second case, probably owing to sickness of the female.

The male is already in the nest calling the female to a new nesting cycle. How quickly the renewal of these things takes place. At once the male invites a renewal of the nesting cycle. The female, however, does not seem to feel quite well—perhaps somewhat exhausted, and possibly her digestion is not normal. I saw her throwing up her food the evening after she laid the first egg. (R 29.)

In the third cycle of the above pair both eggs failed to hatch, and they were deserted on the seventeenth day, shortly after they were due to hatch. Since the period of sitting continues (with feeding of young) for a week after the eggs hatch, evidently the termination of the activity is connected with the failure of the eggs to hatch.

PASSENGER-PIGEON MALE AND RING-DOVE FEMALE.

FIRST CYCLE.

The account starts on January 9, when the female was expected to lay. The pair had evidently been mated previously, and had entered the first part of the mating period. This record is unusual in the length of this mating period; it covers 17 days, exclusive of that portion preceding the record. The female persisted here in continuing the incubation activities for 11 days in spite of a number of defective conditions. Only one egg was laid, which was broken after 3 days; she was subject to the sexual attentions of the male; probably the male failed to alternate in the task of incubation; she was driven from the nest for 5 nights and forced to take the perch. This driving finally broke up the incubating impulse, and the female took the perch of her own accord and began to receive the male. The male participated in the incubation regularly until the egg was broken (3 days). Although no definite statements are made, it is probable that this event very soon terminated the incubating impulse of the male. He certainly made sexual advances to his mate, and it is highly improbable that he continued to alternate with the female without the fact being noted.

On Jan. 9 this female was expected to lay for the first time in life. I found her on the nest at 3^h 50^m and kept watch in order to get the exact time. She behaved as if she was

just ready to lay. She remained on the nest until 5^h 30^m, came off for a minute, returned, and came off again in about a minute. She went back almost immediately, but stopped on the edge of the nest-box. Here she sat quietly until 7^h 25^m, when frightened by something—probably an owl appearing at the window—she flew to the floor and her mate flew to another corner of the pen. After a few moments the female went back to the edge of the nest-box, where she remained all night, returning to the nest early in the morning. She evidently went through the preliminaries to laying, but was a little premature in her actions. By experience she will learn to waste less time in fruitless formalities over such a small matter as laying an egg.

Jan. 10.—To my surprise the female pays little attention to the nest as 4 o'clock draws near. She was on the nest early in the morning and nested for considerable periods during the day, but when the time for laying came, she was off and is now on the perch, apparently for the night.

Jan. 12.—This female has not laid yet. She works at the nest a good deal in the forenoon, but less in the afternoon. She goes to the nest towards 4 o'clock but does not stay more than a few minutes, certainly not more than half an hour. She is on the perch to-night.

Jan. 19.—After 10 days there are still no eggs. The female has recently spent less time on the nest, and sometimes she seems to have given up nesting for the present.

Jan. 23.—The female spent some time in the forenoon in making a nest, her mate bringing the straw. She has not been on the nest of afternoons to stop long, and has taken the perch every night.

Jan. 26.—To my surprise the female (*L* 2) has laid her first egg this afternoon, between 3 and 5^h 30^m—17 days after I expected it. The time has dragged on at such length, and she has given so little sign of laying, that I did not keep close watch of her to-day.

Elsewhere the editor finds a detailed daily record of this pair covering 3 days, a brief synopsis of which is here given: The first egg was laid on Jan. 26 between 3 and 5^h 30^m. She sat over night on the egg, but not closely, and kept the nest until 10^h 20^m a. m. of the next day, when she was relieved by the male. On the 27th the pair alternated on the nest and in carrying straws. Similar behavior obtained for the 28th. The egg was broken on the 29th, and the detailed record was terminated. There was no second egg laid.

Feb. 1.—The female began yesterday to sit at night, and I made her sit on the perch. She did the same to-night. Whether she sat on the nights of the 29th and 30th I am not certain. The egg was broken and removed on the 29th. *Her sitting is therefore certainly a part of the regular routine on which she was started when the egg was laid. She now keeps it up although the egg is removed.*

Feb. 4.—That *L* 2 is still in her course of incubation is shown also by her indifference to the male. She has taken her nest every night thus far and I have removed her every night. Yesterday a union took place, probably the first since the incubation period began.

Feb. 6.—To-night is the first time that *L* 2 has taken her place on the perch without being driven from her nest. She has been trying to sit at night ever since her first egg was laid on January 26, *i. e.*, for 10 days. Driving her off every night has at last broken up the incubation course, and to-day I noticed several sexual unions. (R 18, R 19.)

SECOND CYCLE.

In this cycle the female continued the incubation for a period of 10 days (probable) after a normal mating period, in spite of the following defective conditions: Absence of both eggs, without even the stimulus of the act of laying, the absence of interchange with the male (probable), the probable sexual advances of her mate, and

being forced from the nest and driven to the perch. Apparently the only possible stimulus of the incubating impulse in this case must be found in the previous activities of courting and mating. The author makes no specific reference to the male. In all probability the incubating impulse was not awakened in the male.

The previous cycle was broken up by driving the female from the nest at night. The new cycle began on the 6th; on this date she first took the perch at night of her own accord and sexual unions first began to occur freely. The later records are given in the following excerpts:

Feb. 7.—The female takes her place on the perch to-night for the second time without help.

Feb. 8.—*L 2* went on the perch to-night, of her own accord, for the *third* time.

Feb. 9.—*L 2* is again on the perch. The male tried to induce her to build a nest to-day, but she did not stop long.

Feb. 24.—After sitting on the perch at night for a week or so (since Feb. 6), the female again returned, now some days since, to sitting at night without laying. I have driven her off every night, and have sometimes had to cover the nest to keep her off. Still she has kept on trying to sit up to the present. On Feb. 25 she abandoned sitting at night and of her own accord took the perch. The same occurred on the nights of the 26th and 27th. On Feb. 27 she spent some time making a new nest, and on the 28th she spent nearly the whole forenoon receiving straws, the male working almost continuously. (R 19.)

THIRD CYCLE.

In this cycle the male's incubation record was normal for 3 days. He then began to deviate from normal conduct by making sexual advances to his mate. This sexual impulse arose gradually and increased in strength. Its origin can not be due to any external objective conditions, and the author attributes it to much rich food. The sexual impulse does not at first entirely destroy or terminate his impulse toward incubation; it merely interferes with the normal expression of the latter. Incubation was probably not terminated entirely until the female began to respond and unions resulted. The female continued the incubation activities for 9 days in spite of the advances of her mate, his defective participation in incubation, the substitution of a set of old eggs, and the breaking of one egg. The removal of the second egg was apparently the final stimulus necessary to break up the cycle. This cycle is described with much detail in a diary record. It began on February 25, and after a short mating period the first egg was laid on March 1, between 4 and 6 p. m. The second egg was delivered at 9^h 48^m a. m. on March 3. The record was entirely normal for both birds until 5 p. m. March 4. The deviations of the male and the termination of the cycle are described in the following excerpts:

Mar. 4.—At 5^h 02^m p. m. the male tried to crowd into the nest. He fondled the head of the female and appeared to take great delight in his paternal caresses. He pressed so hard to get possession of the nest that I felt anxious for the eggs. He continued to sit beside the female until long after dark, until 8^h 45^m p. m., and then took a place on the edge of the nest-box, close by the female and with his head turned towards her.

Mar. 5.—At 6^h 27^m a. m. the female came off the nest, and the male flew up to the nest and back to the floor of the pen four times. He seemed undecided what to do.

Once he picked a straw out of the nest and carried it away. The record was normal for the remainder of the day.

Mar. 6.—The male did not offer to go on the nest during the entire day. The female was off and on many times. She was frequently led to resign by the male coming to the box, but she was mistaken as to his purpose. He paid no attention to the nest when she left it, except to tear it to pieces and walk roughly over the eggs. I removed the eggs early in the forenoon to another pair, and gave him a pair of old discarded eggs. The female kept on the nest all day, except for short intervals when she left expecting the male to do his part. Several times the male visited the nest and tried to satisfy his passion on his mate, thus forcing her off the nest.

This strange and sudden desertion of the nest by the male was accompanied by attempts to get out of the pen, by flying again and again against the window and then against the wire screen. He appeared extremely restless, and his whole behavior was very different from what it had been hitherto.

Is it possible that too rich food brought his course of incubation to a premature close and stimulated him to renew the cycle of his paternal functions? Is it the same cause in the case of the crested pigeons which leads them to desert their nest after 6 or 7 days? I notice that the desertion of the nest in the latter case begins with a sexual union. When this has happened the birds may keep on for a day or two in care of the nest, but gradually they leave it for a longer and longer time, and in the course of two or three days they cease to return to it. The union may be stimulated by too much hemp seed and (once started) it brings the incubation course to an end and introduces a new cycle.

On Mar. 8 I found that the female had broken one of the old eggs given to them and I removed the other. As soon as she left the nest and began to receive the male he quieted down and eagerly called her to the nest-box. This shows that he is fully prepared for a new course. (R 18.)

CRESTED-PIGEON MALE AND RING-DOVE FEMALE.

FIRST CYCLE.

This pair had an unusually long courting period. It covered 11 days in addition to a period of unknown length which preceded the record. The incubation period began on January 20, and ended on February 8, a period of 20 days. As in the preceding pair (passenger \times ring), the incubation activities continued over a long period, in spite of a number of abnormal conditions—the absence of the act of laying, the absence of eggs, lack of interchange with her mate, and the solicitations of the male. The incubation, furthermore, extended over into the period devoted to the care of the young, so that the latter part of the activity continued also in spite of the absence of the young, and during a period of need for feeding them. Evidently the incubating impulse did not even arise in the case of the male.

On Jan. 9 I expected the female (*GF 1*) of this pair to lay for the first time. I found her on her nest at 3^h 50^m p. m. and kept watch in order to get the exact time. She behaved as if she was just ready to lay. She came off the nest at 4^h 30^m, flew to the floor, and then took her place on the perch beside her mate until 5^h 45^m. At 5^h 45^m, after dark, she went to the nest-box and sat quietly until 7^h 50^m, when she got up on the edge of the nest-box and soon stepped upon the perch close by. She remained on the perch all night, returning to the nest early next morning. She evidently went through the preliminaries to laying, but was a little premature in her actions.

Jan. 10.—To my surprise the female pays little attention to her nest, at the time she should take the nest and lay. She was on the nest early in the morning and during

much of the day; but when the time for laying came, she was off, and is now on the perch apparently for the night.

Jan. 12.—*GF 1* has not laid yet. She works at the nest a good deal in the forenoon, but less in the afternoon. She went to the nest a little before 4 p. m. but remained only a few minutes, or half an hour at the most. She is on the perch to-night.¹

Jan. 19.—After 10 days there are no eggs. *GF 1* has been busy of mornings more or less every day, and to-day her wings droop, showing that she is about ready to lay.

Jan. 20.—At 4^h 30^m p. m., *GF 1* went upon the nest, but came off at about 7. At 7^h 58^m she went on the nest again and remained on all night.

Jan. 21.—During the morning the female was on the nest as usual; she was found on the nest also at 4^h 30^m p. m., but there were no eggs. She came off within 5 minutes and took her usual place on the perch.

Jan. 22.—The female has spent much of the forenoon on the nest; the male meantime has carried straws. About 3^h 30^m p. m. *GF 1* went on the nest, but came off soon and then went back again. At 7^h 15^m I found her on the nest, apparently for the night, but at 10^h 30^m she left the nest and took her usual place beside her mate. At midnight I found her again on the nest.

Jan. 23.—*GF 1* worked on the nest considerably during the morning. She went on the nest about 2^h 30^m in the afternoon, but did not remain steadily, coming off now and then for a few minutes. To-night she is on to remain, but as yet there is no egg.

Jan. 24.—To-day *GF 1* acted, during all the morning, as if she had deserted the nest she had made. She acted like a dove that, after rearing young, is looking for a place at a distance for a new nest. She flew back and forth in a very uneasy manner, trying to get out of the pen. Instead of going to her nest, she went into a box at the opposite side of the pen, where there was no straw, and spent some time there with the male, but no straws were brought to her. At 5 p. m., however, I find her on the nest, and apparently she will remain on overnight, as she did last night.

Jan. 25.—During the morning *GF 1* and her mate were building a nest in the box opposite the one hitherto occupied. This evening she is back again on the old nest for the night. On Jan. 26 she behaved again in the same way. On Jan. 27 she was on and off her nest. She went on at 3^h 30^m p. m., came off at 4^h 25^m, returned at 4^h 26^m, came off at 4^h 45^m, returned at 4^h 53^m, and remained on overnight.

Jan. 30.—The record for the 28th, 29th, and to-day has been about the same as for the 27th, the female sitting every night on the nest. She takes the nest at about the same time that she would if she were alternating with the male.

Feb. 1.—In the morning the female is driven about by the male and the latter is uneasy and evidently is looking for a place for a new nest. He tries very hard to get out of the pen and to interest the female, but she seems comparatively indifferent. In the afternoon the female went on the nest early—at about 3 p. m. She was on at 3^h 30^m when I left and at 5^h 30^m when I returned; she is now on for the night. *The case of (the previously described pair) L 2, first cycle, seems to clear up that of GF 1. GF 1 made a slip in not bringing forth an egg, and has since continued sitting every night just as if she had laid.*

Feb. 4.—*GF 1* has gone on sitting every night. I have allowed her to remain on just to see how long she will continue. Of Feb. 6 I note that she still takes the nest every afternoon about 3^h 30^m to 4 and remains on overnight. This incubation without having laid an egg has now continued since Jan. 20, i. e., for 18 days. She will probably sit a few nights more. The close sitting normally lasts for about 21 days—2 weeks to hatch the eggs and 1 week on the young. On Jan. 7, *GF 1* went on to her nest at 4^h 30^m p. m., which is later than usual.

¹ The records of this female (*GF 1*) are practically identical with those for *L 2*, described in the previous section. Both of these females failed to lay their expected eggs on the same date, Jan. 9, 1897.—EDITOR.

Feb. 8.—To-night *GF 1*, for the first time since Jan. 20, takes her place on the perch beside her mate. She went on the nest at first, but came off of her own accord. Thus ends her incubation of an empty nest for a period of 20 days. The time is so nearly the same as is usually given to eggs and young that there can be no doubt that she has taken a regular course, just as if she had laid. On the following night *GF 1* took the perch for the second time. The male tried during the day to induce her also to build a nest, but she does little as yet.

SECOND CYCLE.

After a normal mating period this pair repeated a part of their previous performance. The female incubated for a week under the same defective conditions. This activity was finally terminated by persistently driving her from the nest.

Feb. 25.—On Feb. 8, *GF 1* ended her 20 days' incubation of an empty nest. On Feb. 10 she paid more attention to the male and spent a short time on the nest receiving straws. After taking the perch for 3 or 4 nights she began sitting again and, although driven off every night, she followed it up for about a week; but on Feb. 19 she took the perch again of her own accord. After taking the perch regularly every night from Feb. 19 to Feb. 24, she laid an egg this afternoon at the normal hour, between 4^h 30^m and 6 o'clock. This is her first egg in life, and it comes after two premature rounds of sitting. She laid a second egg after the usual interval. (R 19.)

BLOND RING MALE AND WHITE RING FEMALE.

This record presents some rather unusual and ambiguous features. The two females *W 1* and *W 2* (*St. alba*) had been together previous to the record, and both were nearly ready to lay. Since the two laid at practically the same time, there being a difference of only one day, it is probable that we here have another case of the pairing of two females resulting in the production of eggs on the part of both. A male called *X* was introduced into the cage with *W 1* two days before her first egg, or five days after she had started on the reproductive cycle of activities. The male attempted sexual advances and persisted in the sexual activity in spite of the lack of an adequate response on the part of the female. The male's incubation activity did not start with the advent of the eggs, but only upon the "cessation of his sexual activity," *i.e.*, after a normal period of 6 days. The female's incubating activity persisted, although there was a lack of interchange with the male, and in spite of the sexual advances of the latter.

This male was later transferred to another female, *W 2*, who, like the male at this time, was in the incubating stage of activities. But the two birds that had separately attained and begun the incubating activity refused to continue it together; the new mating broke the cycle for both, and a new cycle was initiated almost immediately. It is thus probable that the continuance of incubation on the part of the male depends to some extent upon a definite set of external conditions, a particular female, nest, or nest-location, etc.; for a change from one set of conditions to a very *similar* set of conditions was sufficient to break up the activity. The female *W 2* responded very quickly. Probably her discontinuance of incubation was not due entirely to the solicitations of the male, since in the pairs previously discussed it was frequently noted that the female effectively resisted the solicitations of the male for long periods. A predisposing cause may

have been the lack, in the previous cycles of this female, of a masculine companion and participant in the task of incubation; her impulse to sit may have thus been weak at the time. Probably the introduction of a "novel stimulus," namely, of a male to which she was not accustomed, had much to do with the disturbance. This latter fact would account for the disruption of the incubation, but it alone would not account for her ready acceptance of the male. The detailed records which justify the above analysis follow:

Mar. 28.—The male blond ring-dove (X) was purchased to-day. I have placed him with a female white ring-dove called *W 1*. The latter is one of two white rings bought in the previous November and then thought to be male and female; the second white bird, which also proved to be a female, I designated as *W 2*. *W 1* is nearly ready to lay and is inclined to mate. The male is fierce and will not tolerate her presence, so I have to keep her in a small cage within his cage. On the following day the male was still intolerant, but began to yield a little. He went to the box and called; she at once responded and went to him, tried to take the nest, and began cooing in her turn. He endured it a while and then drove her off. He next went to the opposite box and repeated the same behavior with her. She is patient and takes all his abuse. By night he finally gets reconciled to her and condescends to sit beside her.

Mar. 30.—The female laid an egg at about 5 p. m. The male has behaved towards her to-day about the same as yesterday, driving her about a good deal and not permitting her to remain long in the nest. He seemed to accept her when she answered his call to the nest; he often resigned it to her, but would soon return and drive her off and then call her back. Yesterday, and once to-day, I saw him on the perch with her and soliciting her, but without result. I do not think the egg had any chance of being fertilized.

Mar. 31.—This morning the male has been to the nest and the female resigned. He examined the egg, but did not take any interest in it. He did not cover it, but began to call for the female. After a few moments he went over to the opposite box and called, and the female soon returned to her egg. The male is getting more tolerant, leaving the female more quiet on her nest. But he is evidently not in the spirit of sitting, and the presence of the egg does not stimulate him to the act. The decisive stimulus for such an act is thus not external but internal—probably a feeling which comes over a male "periodically," and which he will manifest perhaps only if the external stimulus is also present. This seems to me to be a not unimportant point. At 9^h 45^m a. m., the male went to the nest again, and this time he did not disturb the female, but fondled her head affectionately and then went off as if fully reconciled to her as a mate. All this is the more interesting, as he still has no impulse to sit. He is ready for making a nest and to accept a mate, *but he requires time to generate the impulse to sit*. This impulse naturally follows the period of sexual activity, and he is now in the latter period.

Apr. 1.—The second egg was laid at 8^h 15^m a. m. The male behaves as on yesterday, allowing the female peace on the nest. If she goes to the floor of the cage when he is there he may behave as if he had accepted her or he may drive her unmercifully. At 1^h 30^m p. m. I find the male on the nest and the female on the floor. He sits on the eggs now, but he does not hesitate to come off three times within half an hour in order to pay his attention to a female in the adjoining cage. Each time, however, he goes back to the eggs, and thus seems to have a rising impulse to the function of sitting. Nevertheless, at 2^h 20^m p. m. he came off the nest and, finding the female on the floor of the cage, attacked her fiercely. She flew to the nest, leaving him to his pleasure. The impulse to sit, if there is one, must still be very weak.

[Apr. 2.—The male relieved the female very early, at about 7 a. m., and remained about 10 to 15 minutes on the eggs. He went on the nest again during the middle of the day.

Apr. 3.—The male takes his part in sitting and has, so far as I can see, fully accepted the eggs. This impulse to sit has arisen gradually in the course of 6 days.

As an experiment in mating, I to-day took away female *W 1* and put female *W 2* in her place. *W 2* is the one I first took to be a male, and she is a little lighter in weight than is *W 1*. *W 2* laid one egg on Mar. 31 and the second on Apr. 2. She is thus one day behind *W 1* in egg-laying. Both of the birds of the new pair, male and female, are now in the beginning of the sitting period.

When the new female (*W 2*) was introduced to the cage of the male at 9^h 30^m a. m. the male chased her around for a time on the floor of the cage. I covered up the box in which the eggs of *W 1* had been laid so that the male would not try to sit.¹ After a short time the male went to the opposite box and called. *W 2* responded after a few moments, but seemed indifferent and soon left. The male allowed her to walk about on the perch and the box without attacking her. At 9^h 45^m, while sitting on the perch, the male actually induced *W 2* to come to him, and she put her beak in his. This looks like dispatch as compared with the behavior of this male toward *W 1*. Shortly, however, his disposition to attack returned and he drove her about, though not so violently as he did *W 1*. In the course of the day the male modified his behavior, becoming quite affectionate and attentive. The match is evidently made for good. On Apr. 9, 6 days after mating, female *W 2* laid an egg. (C 7/15.)

HYBRID MALE AND MOURNING-DOVE MALE.

These birds were paired on April 8. The male hybrid unsuccessfully attempted courting during a month. His lack of success was better understood later, when it was learned that his consort was also a male. On May 9 the hybrid began incubation on the floor of the cage and sat steadily night and day. He was given eggs on the 15th and accepted them. He persisted in the incubation for a week longer, or until he and his consort were transferred to a cage out of doors. This hybrid had never been mated. The incubating impulse thus developed and persisted without eggs, nest, interchange with a mate, nest-building, or any sexual intercourse with a mate. The cage of this pair was so placed that none of their own species was visible. (Summarized from C 7/48.)

LEUCOSARCIA PICATA.

A pair of white-faced pigeons kept up their care of the young until it left the nest at the age of 18 days. Two days later the egg of the succeeding cycle was dropped, but it failed to develop. It is noted that "evidently the close care of the young did not give the male a fair chance to fertilize the egg." (Sh 8/13.) Usually the old birds begin to leave the nest near or at the end of 7 days, and cease covering the young entirely by the twelfth day. In this case the unusual persistence of the incubating impulse of one cycle disrupted the normal activities of the succeeding cycle.

MOURNING-DOVE MALE AND WHITE-RING FEMALE.

A male mourning-dove refused to mate properly when paired. He finally courted and united with a female, but took no part in nest-building and incubation. This behavior was repeated in several cycles. The female attempted incubation,

¹ The subsequent record shows, however, that the male made no repeated or prolonged attempt, possibly no attempt at all, to continue sitting in or near the old nest.—EDITOR.

but the eggs failed to develop because of probable lack of fertilization. Thus the initial act does not necessarily stimulate and arouse the succeeding activities of nesting and incubation in the male. The female, however, completed the cycle without the coöperation of a mate in nesting and incubation. "I do not understand this male. Finding that he used the female white ring (*W 1*) for his pleasure, but never mated with her properly, so as to take any part in sitting, I gave him another female." (*C 7/7.*)

HOMER MALE AND HYBRID FEMALE.

This pair, consisting of a male homer and a hybrid, was mated on May 29. "They paired, courted, united, built a nest, but *never* laid or sat." (*BB 5.*) This phenomenon, according to Dr. Riddle, occurs perhaps more frequently among hybrid females than among non-hybrids. Dr. Whitman cites at least one such case in domestic pigeons, and notes that this failure on the part of the female was a mark of "degeneracy."

ECTOPISTES.

In crossing common pigeons with the wild species one finds that the former usually keep up incubation for a few days after their usual time. The wild passenger-pigeon never waits more than 10 or 12 hours. If the egg does not hatch within that time he leaves it; no matter if the shell is broken and the bird nearly ready to hatch, it is deserted. The common pigeons, however, are a little less particular in this respect than are the wild species.

The egg of a ring-dove mated to a passenger-pigeon developed up to a few days of hatching, but died for some unknown cause. The male passenger was then flying back and forth, calling as he flew. He was evidently at the end of his period, and as he got nothing to feed, his impulse turned in the direction of seeking a place for a new nest. His incubation period is thus seen to be cut short if the egg fails to hatch. The same is true of the crested pigeons. The ring-dove will keep on sitting for 20 days in many cases, or even longer. (*SS 10, SS 4.*)

MISCELLANEOUS.

(1) The pairing of two males, as described in Chapter III, constitutes a defective cycle. Two males may pair, court, unite, and incubate an empty nest. If given eggs, they may hatch them and feed and care for the young. The cycle is thus completed without the presence or production of eggs, and with an unusual and abnormal sexual response. Upon the desertion or death of the female, the male may continue incubation, doing double duty, in spite of the absence of a partner and of her lack of participation in incubation.

A male will often sit on eggs or young at night, in case the female deserts or dies. An example of the latter has just occurred where a male ring-dove is sitting at night on young only a few days old.

(2) In a pair of female ring-doves (pair *D*; see Chapter III), the first egg was laid on January 26. The supposed male attempted to take the nest at this time, but was driven away. He then went to an empty nest and persisted in sitting in spite of being driven off until the act was broken up by covering the nest. He

then began incubation of the eggs on January 29, and normal conduct was exhibited thereafter. In the second cycle the one female laid on February 27 and 29 and the supposed male did not begin incubation until March 3, when she too laid an egg. Another pair (*E*) mated and went through all the preliminaries, even to the symptoms of laying. Neither bird laid, however, but incubation began at the usual time. For the most part both birds sat on the nest at night and exchanged with each other during the day. This incubation persisted for the usual time, when a new cycle was started and one of the pair laid eggs. In another case both females laid in one nest and exchanged with each other as if male and female. The preliminary activities of courting, uniting, and nesting are abnormal in one bird, and they find no normal reciprocal response in the other. Following these, the production of eggs may be lacking in one or both of the pair, although some of the correlated behavior may be present. The production of eggs may be stimulated in both birds, and when this occurs the previous masculine behavior is associated with delayed laying. The impulse to incubate develops in both birds, although eggs are lacking. This impulse was not awakened in one bird until after the delayed laying. Incubation persisted in spite of defective alternation, and also, in the case of one of the females of "pair *D*," in spite of an empty nest and being driven away and having the box covered.

(3) Several times this season and in different pairs, such as ring-dove \times Japanese turtle, *tur-orient.* \times *tur-orient.* hybrids, *orientalis* \times *turtur*, *guinea* \times *guinea* hybrids, etc. (and formerly crested pigeons, which laid several times before sitting steadily), I have seen eggs laid and incubation begun, and in the course of a few days or a week the eggs were deserted.

In the case of the *turtur-orientalis* hybrids, the offenders were young birds. They began by laying and sitting well for a few days or a week, then beginning a new nest and laying again, and again incubating for a short time. I believe this is due to having "an abundance of rich food," and to eating more than is really needed, thus bringing forward a set of eggs that would, under normal nourishment, not develop until the previous set hatched and the young were reared. After the birds have repeated this several times, and as the season is more advanced, they become exhausted to an extent that allows of a normal course of incubation. As an example of this, two pairs of Japanese turtle \times European turtle, and also one of the reciprocal cross, have repeated the short abnormal course four or five times, but they are now at work in normal time.

(4) The time of incubation, or rather the time that the old bird will continue her sitting, can be varied somewhat as the result of excessive feeding. The bird becomes unsteady in sitting and then begins a new cycle, and in several cases I have found pairs of birds producing a second and even a third set of eggs in the same nest. One pair of crested pigeons, for example, after they had sat a week on one set of eggs, laid two more in the same nest; and then after a week or ten days more laid a third pair of eggs in the same nest. These birds were kept indoors and had plenty of stimulating food, hemp and canary seed; and I saw no other reason than the easy conditions under which they were kept which should lead them to break the cycle in this way—to stop the sitting on one set of eggs and renew the sitting on another set of eggs in the same nest.

(5) A pair consisting of a ring-dove and a Japanese turtle have twice raised young, and each time they have laid again before the young were out of the nest. As a result, the later eggs were deserted and the young were thus given more time to get out of the way, and then other eggs were laid which were properly incubated.

(6) Any serious fright or disturbance is likely to cause desertion. In a pair of mourning-doves it was noted that the eggs were deserted on the second day of incubation as a result of disturbance by dogs. A pair of homers deserted their young when 10 days old in order to return to a former nest. Other pairs, however, failed to desert their eggs in similar circumstances (Chapter X). A change in the position or character of the nest may also cause desertion of eggs or young (Chapter XII). (R 7, R 18, SS 10, Em 7.)

(7) Two male mourning-doves, after the normal end of their breeding season, indulged in all the preliminaries of courting, uniting, and nesting, but failed entirely to incubate, or else did so quite spasmodically. It is noted that this phenomenon occurred only with males which were unusually prolific and unusually successful in fertilizing eggs (see under "Prolongation of the Breeding Season in Wild Pigeons," Chapter I). At the period of the subsidence of the reproductive impulses, it was found that the sexual proclivities were still vigorous and found expression, while the incubating impulse was extremely weak and sometimes failed altogether. It is thus possible that, in the disintegration of the reproductive series of acts at the end of the season, the incubating impulse tends normally to disappear first, or that we are here dealing with males in which the sexual impulse is relatively much stronger than usual. From the short account of the phenomenon the latter interpretation is to be preferred, though one is not justified in making a decision.

(8) In his breeding experiments the author frequently removed the eggs shortly after being laid and had them hatched under a pair of "brooders." This removal of the eggs generally disrupts the cycle immediately. To assure the disruption, however, the nest-box is usually temporarily displaced or removed. In the treatment of the topic, "Length of the Mating Period," in Chapter I, 27 such cases are listed. Many hundreds of cases could have been obtained from the "breeding records." In one case it is stated that the female persisted in sitting for some time (probably 10 days) afterwards. The breaking of the eggs usually produces the same effect; 4 such cases are listed in the same place cited above, while in one case the new cycle was postponed for about 10 days.

CHAPTER VIII.

THE GENETIC STANDPOINT IN THE STUDY OF INSTINCT.

This chapter is composed entirely of a selection from Professor Whitman's lectures on Animal Behavior delivered at the Marine Biological Laboratory at Woods Hole in 1897 and 1898. Although these lectures have been published,¹ it has been deemed advisable to insert this selection at this point, as it presents in a very succinct form the author's view of instinct in general as well as an admirable treatment of the instinct of incubation.

GENEALOGICAL HISTORY NEGLECTED.

The problem of psychogenesis requires a more definite genetic standpoint than that of general evolution. It is not enough to recognize that instincts have had a natural origin, for the fact of their connected genealogical history is of paramount importance. From the standpoint of evolution as held by Romanes and others, instincts are too often viewed as disconnected phenomena of independent origin. The special and more superficial characteristics have been emphasized to the exclusion of the more fundamental characters.

Biologists and psychologists alike have very generally clung tenaciously to the idea that instincts, in part at least, have been derived from habits and intelligence; and the main effort has been to discover how an instinct could become gradually stamped into organization by long-continued uniform reactions to environmental influences. The central question has been: How can intelligence and natural selection, or natural selection alone, initiate action and convert it successively into habit, automatism, and congenital instinct? In other words, the genealogical history of the structural basis being completely ignored, how can the instinct be mechanically rubbed into the ready-made organism? Involution instead of evolution; mechanization instead of organization; improvisation rather than organic growth; specific *versus* phyletic origin.

This inversion, or rather perversion, of the genealogical order leads to a very short-focussed vision. The pouting instinct is supposed to have arisen *de novo*, as an anomalous behavior, and with it a new race of pigeons. The tumbling instinct was a sort of *lusus naturæ*, with which came the fancier's opportunity for another race. The pointing instinct was another accident that had no meaning except as an individual idiosyncrasy. The incubation instinct was supposed to have arisen after the birds had arrived and laid their eggs, which would have been left to rot had not some birds just blundered into "cuddling" over them and thus rescued the line from sudden extinction. How long this blunder-miracle had to be repeated before it happened all the time does not matter. Purely imaginary things can happen on demand.

THE INCUBATION INSTINCT.

1. *Meaning to be sought in phyletic roots.*—It seems quite natural to think of incubation merely as a means of providing the heat needed for the development of the egg, and to assume that the need was felt before the means was found to meet it. Birds and eggs are thus presupposed, and as the birds could not have foreseen the need, they could not have hit upon the means except by accident. Then, what an infinite amount of chancing must have followed before the first "cuddling" became a habit, and the habit a perfect instinct!

¹ Biological Lectures, Woods Hole, 1898, pp. 285-338, Boston.

We are driven to such preposterous extremities as the result of taking a purely casual feature to start with. Incubation supplies the needed heat, but that is an incidental utility that has nothing to do with the nature and origin of the instinct. It enables us to see how natural selection has added some minor adjustments, but explains nothing more. For the real meaning of the instinct we must look to its phyletic roots.

If we go back to animals standing near the remote ancestors of birds, to the amphibia and fishes, we find the same instinct stripped of its later disguises. Here one or both parents simply remain over or near the eggs and keep watchful guard against enemies. Sometimes the movements of the parent serve to keep the eggs supplied with fresh water, but aeration is not the purpose for which the instinct exists.

2. *Means rest and incidental protection to offspring.*—The instinct is a part of the reproductive cycle of activities, and always holds the same relation in all forms that exhibit it, whether high or low. It follows the production of eggs or young and means primarily, as I believe, *rest*¹ with incidental *protection to offspring*. That meaning is always manifest, no less in worms, mollusks, crustacea, spiders, and insects than in fishes, amphibia, reptiles, and birds. The instinct makes no distinction between eggs and young, and that is true all along the line up to birds, which extend the same blind interest to one as to the other.

3. *Essential elements of the instinct.*—Every essential element in the instinct of incubation was present long before the bird and eggs arrived. These elements are: (1) the disposition to remain with or over the eggs; (2) the disposition to resist and to drive away enemies; and (3) periodicity. The birds brought all these elements along in their congenital equipment and added a few minor adaptations, such as cutting the period of incubation to the need of normal development and thus avoiding indefinite waste of time in case of sterile or abortive eggs.

(1) *Disposition to remain over the eggs.*—The disposition to remain over the eggs is certainly very old and is probably bound up with the physiological necessity for rest after a series of activities tending to exhaust the whole system. If this suggestion seems far-fetched, when thinking of birds, it will seem less as we go back to simpler conditions, as we find them among some of the lower invertebrate forms, which are relatively very inactive and predisposed to remain quiet until impelled by hunger to move. Here we find animals remaining over their eggs, and thus shielding them from harm, from sheer inability or indisposition to move. That is the case with certain mollusks (*Crepidula*), the habits and development of which have been recently studied by Professor Conklin.² Here full protection to offspring is afforded without any exertion on the part of the parent in a strictly passive way that excludes even any instinctive care. In *Clepsine* there is a manifest unwillingness to leave the eggs, showing that the disposition to remain over them is instinctive. If we start with forms of similar sedentary mode of life, it is easy to see that remaining over the eggs would be the most likely thing to happen, even if no instinctive regard for them existed. The protection afforded would, however, be quite sufficient to insure the development of the instinct, natural selection favoring those individuals which kept their position unchanged long enough for the eggs to hatch.

(2) *Disposition to resist enemies.*—The disposition to keep intruders from the vicinity of the nest I have spoken of as an element of the instinct of incubation. At first sight it seems to be inseparably connected with the act of covering the egg, but there are good reasons for regarding it as a distinct element of behavior. In birds this element manifests itself before the eggs are laid, and even before the nest is built; and in the lower animals the disposition to cover the egg is not always accompanied by an aggressive attitude. This attitude is one of many forms and degrees. A mild self-defensive state, in which the

¹ This is an important point in connection with the phenomenon of "weakened germs," resulting from rapid egg-laying without intervening incubations—a subject dealt with in Volume II.—EDITOR.

² Journ. of Morph., Vol. XIII, No. 1, 1897.

animal merely strives to hold its position without trying to rout intruders, would perhaps be the first stage of development. In some of the lower vertebrates the attitude remains defensive and is aggressive only in a very low degree, while in others pugnacity is more or less strongly manifested. Among fishes the little stickleback is especially noted for its fiery pugnacity, which seems to develop suddenly and simultaneously with the appearance of the dark color of the male at the spawning season.

In pigeons, as in many other birds, this disposition shows itself as soon as a place for a nest is found. While showing a passionate fondness for each other, both male and female become very quarrelsome towards their neighbors. The white-winged pigeon (*Melopelia leucoptera*) of the West Indies and the southern border of the United States is one of the most interesting pigeons I have observed in this respect. At the approach of an intruder the birds show their displeasure in both tone and behavior. The tail is jerked up and down spitefully, the feathers of the back are raised as a threatening dog "bristles up," the neck is shortened, drawing the head somewhat below the level of the raised feathers, and the whole figure and action are as fierce as the bird can make them. To the fierce look, the erect feathers, the ill-tempered jerks of the tail, is added a decidedly spiteful note of warning. If these manifestations are not sufficient, the birds jump toward the offender, and if that fails to cause retreat, wings are raised and the matter settled by vigorous blows.

The pugnacious mood is periodical, recurring with each reproductive cycle and subsiding like a fever when its course is run. The birds behave as if from intelligent motive, but every need is anticipated blindly; for the young pair, without experience, example, or tradition, behave like the parents.

It seems to me that this mood or disposition, although in some ways appearing to be independent of the disposition to cover the eggs, can best be understood as having developed in connection with the latter. It has primarily the same meaning—protection to the eggs—but the safety of the eggs and young depends upon the safety of the nest, and this accounts for the extension of its period to cover all three stages—building, sitting, and rearing.

(3) *Periodicity*.—The periodicity of the disposition to sit coincides in the main with that of the recuperative stage. Its length, however, at least in birds, is nicely correlated with, though not exactly coinciding with, the time required for hatching. It may exceed or fall short of the time between laying and hatching. The wild passenger-pigeon (*Ectopistes*) begins to incubate a day or two in advance of laying, and the male takes his turn on the nest just as if the eggs were already there. In the common pigeon the sitting usually begins with the first egg, but the birds do not sit steadily or closely until the second egg is laid. The birds do not, in fact, really sit on the first egg, but merely stand over it, stooping just enough to touch the egg with the feathers. This peculiarity has an advantage in that the development of the first egg is delayed so that both eggs may hatch more nearly together. The bird acts just as blindly to this advantage as *Ectopistes* does to the mistake of sitting before an egg is laid. *Ectopistes* is very accurate in closing the period, for if the egg fails to hatch within 12 to 20 hours of its normal time, it is deserted, and that too if, as may sometimes happen, the egg contains a perfect young, about ready to hatch.

Pigeons, like fowls, will often sit on empty nests, filling up the period prescribed in instinct, leaving the nest only as the impulse to sit runs down. It happens not infrequently that pigeons will go right on with the regular sequence of activities, even though nature fails in the most important stage. Mating is followed by nest-making, and at the appointed time the bird goes to the nest to lay, and after going through the usual preliminaries brings forth no egg. But the impulse to sit comes on as if everything in the normal course had been fulfilled, and the bird incubates the empty nest and exchanges with her mate as punctiliously as if she actually expected to hatch something out of nothing. This may happen in any species under the most favorable conditions. It is possible by giving an abundance of rich food to wind up the instinctive machinery more rapidly than would

normally happen, so that recuperation may end in about a week's time, when incubation will stop and a new cycle begin, leading to the production of a second set of eggs in the same nest. This has happened several times with the crested pigeon of Australia (*Ocyphaps lophotes*).

Schneider says:¹ "The impulse to sit arises, as a rule, when a bird sees a certain number of eggs in her nest." Although recognizing a *bodily disposition* as present in some cases, sitting is regarded as a *pure perception impulse*. I hold, on the contrary, that the bodily disposition is the universal and essential element, and that sight of the eggs has nothing to do primarily with sitting. It comes on only secondarily and as an adaptation in correlation with the inability in some species to rear more than one or two broods in a season. In such species the advantage would lie with birds beginning to incubate with a full nest.

The suggestions here offered on the origin of the incubation instinct, incomplete and doubtful as they may appear, may suffice to indicate roughly the general direction in which we are to look for light on the genesis of instincts. The incubation instinct, as we now find it perfected in birds, is a nicely timed and adjusted part of a periodical sequence of acts. If we try to explain it without reference to its physiological connections in the individual, and independently of its developmental phases in animals below birds, we miss the more interesting relations and build on a purely conjectural chance act that calls for a further and incredible concatenation of the right acts at the right time and place, and is not even then completed until its perpetuation is secured by a miracle of transmission.

A FEW GENERAL STATEMENTS.

(1) Instinct and structure are to be studied from the common standpoint of phyletic descent, and that not the less because we may seldom, if ever, be able to trace the whole development of an instinct. Instincts are evolved rather than involved (stereotyped by repetition and transmission), and the key to their genetic history is to be sought in their more general rather than in their later and incidental uses.

(2) The primary roots of instincts reach back to the constitutional properties of protoplasm, and their evolution runs, in general, parallel with organogeny. As the genesis of organs takes its departure from the elementary structure of protoplasm, so does the genesis of instincts proceed from the fundamental functions of protoplasm. Primordial organs and instincts are alike few in number and generally persistent. As an instinct may sometimes run through a whole group of organisms with little or no modification, so may an organ sometimes be carried on through one or more phyla without undergoing much change. The dermal sensillæ of annelids and aquatic vertebrates are an example.

(3) Remembering that structural bases are relatively few and permanent as compared with external morphological characters, we can readily understand why, for example, 500 different species of wild pigeons should all have a few common undifferentiated instincts, such as drinking without raising the head, the cock's time of incubating from about 10 a. m. to about 4 p. m., etc.

(4) Although instincts, like corporeal structures, may be said to have a phylogeny, their manifestation depends upon differentiated organs. We could not, therefore, expect to see phyletic stages repeated in direct ontogenetic development, as are the more fundamental morphological features, according to the biogenetic law. The main reliance in getting at the phyletic history must be comparative study.

(5) Instinct precedes intelligence both in ontogeny and phylogeny, and it has furnished all the structural foundations employed by intelligence. In social development also instinct predominates in the earlier, intelligence in the later stages.

(6) Since instinct supplied at least the earlier rudiments of brain and nerve, since instinct and mind work with the same mechanisms and in the same channels, and since

¹ Der Thierische Wille, pp. 282, 283, as cited in Professor James's Psychology, p. 388.

instinctive action is *gradually* superseded by intelligent action, we are compelled to regard instinct as the actual germ of mind.

(7) The automatism, into which habit and intelligence may lapse, seems explicable, in a general way, as due more to the preorganization of instinct than to mechanical repetition. The habit that becomes automatic, from this point of view, is not an action on the way to becoming an instinct, but action preceded and rendered possible by instinct. Habits appear as the uses of instinct organization which have been learned by experience.

(8) The suggestion that intelligence emerges from blind instinct, although nothing new, will appear to some as a complete *reductio ad absurdum*. But evolution points unmistakably to instinct as nascent mind, and we discover no other source of psychogenetic continuity. As far back as we can go in the history of organisms, in the simplest forms of living protoplasm, we find the sensory element along with the other fundamental properties, and this element is the central factor in the evolution of instinct, and it remains the central factor in all higher psychic development. It would be strange if, with this factor remaining one and the same throughout, organizing itself in sense-organs of the keenest powers and in the most complex nerve mechanisms known in the animal world—it would be strange if, with such continuity on the side of structure, there should be discontinuity in the psychic activities. Such discontinuity would be nothing less than the negation of evolution.

(9) We are apt to contrast the extremes of instinct and intelligence—to emphasize the blindness and inflexibility of the one and the consciousness and freedom of the other. It is like contrasting the extremes of light and dark and forgetting all the transitional degrees of twilight. In so doing we make the hiatus so wide that derivation of one extreme from the other seems about as hopeless as the evolution of something from nothing. That is the last pit of self-confounding philosophy.

Instinct is blind; so is the highest human wisdom blind. The distinction is one of degree. There is no absolute blindness on the one side and no absolute wisdom on the other. Instinct is a dim sphere of light, but its dimness and outer boundary are certainly variable; intelligence is only the same dimness improved in various degrees.

When we say instinct is blind we really mean nothing more than *it is blind to certain utilities* which we can see. But we ourselves are born blind to these utilities, and only discover them after a period of experience and education. The discovery may seem to be instantaneous, but really it is a matter of growth and development, the earlier stages of which consciousness does not reveal.

Blindness to the utilities of action no more implies unconsciousness in animals than in man. It is the worst form of anthropomorphism to claim that animal automatism is devoid of consciousness, for the claim rests on nothing but the assumption that there are no degrees of consciousness below the human. If human organization is of animal origin, then the presumption would be in favor of the same origin for consciousness and intelligence. Automatism could not exclude every degree of consciousness without excluding every form of organic adaptation.

(10) The clock-like regularity and inflexibility of instinct, like the once-popular notion of the "fixity" of species, have been greatly exaggerated. They imply nothing more than a low degree of variability under normal conditions. Discrimination and choice can not be wholly excluded in every degree, even in the most rigid uniformity of instinctive action. Close study and experiment with the most machine-like instincts always reveal some degree of adaptability to new conditions. This was made clear by Darwin's studies on instincts, and it has been demonstrated over and over again by later investigators, and by none more thoroughly than by the Peckhams in the case of spiders and wasps.¹ Intelligence implies varying degrees of freedom of choice, but never complete emancipation from automatism. The fundamental identity of instincts and intelligence is shown in *their dependence upon the same structural mechanisms and in their responsive adaptability*.

¹ Wisconsin Geological and Natural History Survey Bulletin No. 2, 1898.

CHAPTER IX.

REPRODUCTIVE CYCLE—SUMMARY AND ANALYSIS.

The present chapter attempts, for the convenience of the reader, an editorial summary of the various facts, principles, and interpretations of the previous material, with occasional additional comment and suggestion. The reproductive cycle may be conveniently divided into four groups of activities whose temporal relations are represented in figure 1. The sexual activities are represented by *M*; *N* and *F* refer to the nesting and feeding activities respectively; while *I* stands for the incubation of the eggs and young. The variation in thickness expresses the gradual rise of the impulse to its maximal strength and its gradual decline and final disappearance. The length of the lines expresses the relative duration of the activities, each unit of length representing a day. Since these periods are highly variable in length, we have arbitrarily chosen values which approximate an average.

DESCRIPTIVE SUMMARY.

(1) *The sexual activities* extend over a period of 7 days. They are difficult to describe in any fixed temporal order, since the composition and order of events seem to vary with the state of excitement, the reciprocal response of the mate, and the general progression of events in the cycle. The same bit of behavior may occur in several connections and have a variable meaning and purpose. Only a logical analysis and summary of the simpler elements of behavior is possible. The preliminary acts mentioned are billing or pecking at their own feathers on the wings and certain parts of the tail; preening and shaking the feathers; elaborate bowing and cooing; going to the nest and giving the nest-call; approaching the mate; giving amorous glances; wagging the wings; lowering the head; swelling the neck; raising

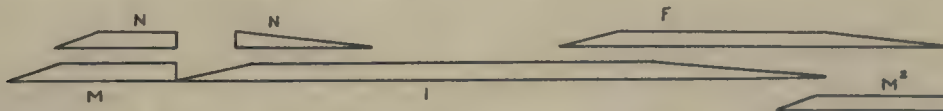


FIG. 1.—*M*, mating period; *N*, nesting activities; *I*, incubation of eggs and young; *F*, feeding of young; *M*², mating period of second cycle.

the wings; raising and spreading the tail and feathers on the back and rump; alternately stamping and striking the feet and wagging the body from side to side, and strutting with drooping wings. Charging and driving may be resorted to in the courtship. The male walks or rushes at the female, holds the head high, lowers the wings, exhibits excitement, elevates the back, erects the feathers, pecks perfunctorily or petulantly, clucks, and gives the driving coo consisting of three notes,¹ with raised wings, raised and spread tail, while the beak is on the floor.

¹ This and some other features of behavior apply particularly to bronze-wing pigeons.—EDITOR.

As the period of consummation approaches, the composition of the activities changes with the addition of new elements. Along with bowing, there is billing and fondling of each other's head, hugging or necking, jumping over the female without any attempt at mounting, opening the beak by the male, inserting of female's beak in his, and often the shaking and rattling of the crop as if the male fed the female. The female stoops with lowered head, the male mounts with a jump, the female raises her wings as a support and lifts the tail, while the male reaches back, moving the tail from side to side until contact is effected. The subsequent actions vary with the species; some slip off at once, while others recover the position and remain still a moment; and, in addition to this, the bronze-wings lower the head and wings, give a series of seven rising notes, and jump off with a wing-slap at the final note. After dismounting, some species lower the tail and wings, raise and arch the neck, and strut around the female; others bristle up and drive the female, and some raise the head with the beak pointing upwards.

(2) *The nesting activities* are initiated two days after the beginning of the cycle and thereafter the nesting and sexual impulses alternate in their dominance of the bird's behavior. The onset of the impulse is manifested by uneasiness, restlessness, indecision, and restrained flying movements which finally eventuate into an overt search for a nesting site. In a second cycle some birds invariably seek a new location, and this instinctive tendency is so strong that it persists in a cage with no opportunity for adequate expression. So far as the records go, the male appears to take the initiative in the search. Either bird may become satisfied with a site, while the other remains undecided for some time. The selection is rendered evident by the bird's remaining near the chosen spot and giving the nesting-call to the mate. The selection becomes certain with the initiation of nest-building. The nest-building activities under the artificial conditions of close confinement are exhibited in a rather rudimentary and spasmodic manner with varying degrees of strength and completeness.¹

Usually the female stays on the nest and works at its construction, while the male carries the straw. One straw only is carried at a time, and in delivery the male of some species mounts the back of the female and places it in front of her. The female fashions the nest with certain movements of the legs, feet, and body. The nest-building ceases for several days at the time of egg-laying, but is resumed again with the initiation of incubation and extends throughout about half of that period. During incubation either bird may carry straws to the one on the nest. The nest-call is given frequently during these nesting activities and this probably influences the activities of the other bird to some extent. The male's call, in bronze-wings, consists of a single note, one second long, clear and hollow and like the moan or groan of a cat. It is given at a varying rate and with a varying loudness and

¹ It is a general rule that the female remains in the nest and receives straws which are brought by the male. If, however, the female while on the ground happens to notice a straw, she may seize it and carry it up. After laying, the female not uncommonly brings straws to the male in the nest. If two males become mated, usually the stronger, more masculine bird plays the part of male, while the other becomes docile and in all respects like a female. In such cases the docile male will sit in the nest and receive straws brought by the other bird. (Conv. 9/2/07, W. C.)

earnestness. It is sometimes accompanied with nods of the head, the beak being held vertically downward. These nods are the more pronounced as the calls increase in loudness and earnestness. The call is also accompanied by wing-movements similar to those of the young in appealing for food. These vary in amplitude with the earnestness of the call. The female's call is, in these forms, a single husky, jarring, vibratory note with a duration of three-fourths of a second. Its strength is less than that of the male, and it is given at a variable rate. It is accompanied by slight head nods and the beak is slightly opened.

(3) *In egg-laying* the bird exhibits diagnostic symptoms for several days previous to ovulation, and apparently the length of this period can be curtailed as a result of experience. The symptoms mentioned are, sitting in the nest, drooping wings, sickly appearance, and heavy movements. In laying, the bird moves well forward in the nest, assumes an erect position with the head and fore-parts raised and the rump lowered at an angle of 45° , raises the tail, exhibits an attitude of strain and sometimes of pain and agony, exhibits intermittent moments of labor, gives in some cases the nest-call occasionally throughout the operation, raises the wings to the horizontal with the head thrown back and half around and with beak raised as the egg drops, and then stands motionless for a variable time with closed eyes, cuddles the egg with the bill, and then usually settles down on the nest. The egg invariably comes small end first. The number of eggs depends upon the species. The first egg is invariably dropped in the afternoon, the exact time varying with the species and the time of the year. The time of the second egg and the interval between the two eggs is a function of the species and the time of the year.

(4) *The onset of incubation* is not necessarily synchronous with the appearance of the first egg; the time varies with the species. With *Ectopistes* both birds start incubation previous to egg-laying. Others begin after this event, the time being somewhat variable. The impulse gradually rises in strength; at first, the birds may merely stand over the eggs and sitting is somewhat intermittent, but shortly after the second egg is dropped incubation becomes continuous. Both birds participate in the nesting duties. The onset of the impulse seems to develop rather independently in the two birds. Generally the male begins incubation later than the female. The female takes the nest during the night, while the male roosts on the perch as far away from the nest as is possible. During the daytime the two alternate on the nest, with the male performing the major portion of the work during this time. The length of this period in which alternation occurs is somewhat variable, probably being somewhat dependent upon conditions of light.

With any defection on the part of either bird, the mate usually attempts continuous incubation until endurance is no longer possible. The exchange is frequently stimulated by the mate's act of taking or leaving the nest. The incubation impulse seems to reach its maximum at the time of hatching and persists for about a week, when incubation becomes intermittent and finally ceases. Apparently the male desists from his duties sooner than does the female. The length of the incubation period is highly variable. Its duration, as represented in figure 1, is

27 days, 16 of which are devoted to the eggs and 11 to the young. The old birds defecate out of the nest and remove the vacated shells and any dead young from the nest. The young also manifest instinctive behavior conducive to the cleanliness of the nest.

(5) *Both birds feed the young by regurgitation.* These activities begin with hatching and the duration of the period is highly variable. Feeding invariably continues after incubation has ceased. Normally the feeding is terminated by the events of the succeeding cycle. The female usually stops feeding with the beginning of the second incubation period, while the male may continue well up to the point of hatching. The food consists at first of "milk," a secretion of the crop. Later this secretion becomes mixed with partially digested food. The young birds stimulate the feeding response by certain attitudes of the body, their cries, flapping of the wings, and the teasing stimulus of their beaks around those of their parents. The old birds open and present their beaks, while those of the young are inserted with vigorous thrusts. The machinery of regurgitation consists of a shaking of the crop, involving movements of the entire body and especially of the wings.

SPECIES DIFFERENCES.

For purposes of reference the various comparative statements of the manuscripts may be summarized. There are probably specific differences in the time and duration of the breeding-season. The essential similarity of *Leucosarcia*, *Geopelia*, bronze-wing, mourning-dove, and the crested pigeon in their display and preliminary courting activities is frequently commented upon. Band-tails deviate from the usual procedure of mouth-billing as a preliminary to mounting. Mounting behavior, up to the point of contact, is uniform, only differences in speed and vigor being noted. The acts subsequent to union are highly variable with the species. The recovery of position by the male is peculiar to the bronze-wing. In some species the male drives the female away, while the opposite attitude is exhibited by others. Uniformity is asserted as to the symptoms of nesting, the tendency to seek a new nesting-site for subsequent cycles, the number of straws carried at a time, and the male's manner of delivery. Apparently each species exhibits distinctive voice characteristics, as is evident in their nesting-calls. Uniformities are mentioned as to the method of egg-laying, the feeding activities, the roosting habits of the male during incubation, feminine incubation at night, and the time of interchange. Differences are noted in the length of the incubation period, the number of eggs laid, the time of laying, and the time of beginning incubation.

One can hardly regard this account as an exhaustive comparative study. The manuscripts indicate that Professor Whitman was apparently more interested in the general uniformities of behavior than in the matter of specific differences. Close confinement under highly artificial conditions would tend to obscure or distort many specific modes of response, such, for example, as the nesting activities of wild species. A note in one of the later manuscripts indicates, however, that the author at that time contemplated a very extensive study of species relationships by means of comparative behavior.

SEX DIFFERENCES.

In the normal reproductive cycle many acts are performed by both birds. Either bird may make advances, bill its own feathers, bow, coo, bill the other's head, stamp and strike the feet, hug and neck, and, in one species, strive to obtain the upper hold for mounting. Under certain conditions, bronze-wings of either sex may stoop and receive the mate, and either may mount and exhibit all of the characteristics of uniting behavior. Both participate in the search for and selection of the nesting-site, and during the incubation period each bird takes its turn in carrying straws and arranging them in the nest. Both incubate the eggs and the young and both participate in the feeding of the young.

Within this *common group* of activities, the sexes normally differentiate themselves in the characteristics of initiative, vigor, energy, and aggressiveness, and in the frequency and completeness of many of the acts. The male, even in the bronze-wings, is the more initiative and aggressive; his acts are performed with more energy and vigor; the male bows, coos, stamps his feet, and mounts more frequently. The female spends more time on the nest; she begins incubation somewhat earlier than the male, continues it longer, and puts in more time per day. The mounting activities of the female bronze-wing are infrequent, rather incomplete, and much reduced in energy and life.

Certain activities in the normal cycle are also *peculiar* to each sex. The activities normally manifested by the male alone are: Jealousy, display, charging and driving, jumping over, presenting the open beak in billing, carrying straw for the nest in the period prior to incubation, incubating by day only, and roosting away from the nest at night. The acts peculiar to the female are retreating from the driving male, insertion of the beak in billing, nest construction in the period before incubation, egg-laying with its preliminary symptoms, and incubation by night.

In the unnatural pairings of like sexes, however, it has been found that most of those acts which are normally characteristic of the one sex may be exhibited by the opposite sex. Under these conditions, a female may also charge and drive, exhibit jealousy, jump over, present the open beak and receive that of the mate, carry straw, incubate by day, and roost away from the nest at night. The only masculine act not noted for the female was *display*. Under these unnatural conditions the male may also retreat, insert the beak in billing, construct the nest, and incubate at night. The egg-laying activities, from the nature of the case, can not be (fully) manifested by males playing the feminine rôle, and possibly this fact is due merely to the absence of the necessary stimulating intraorganic conditions (ovulation). When either bird thus plays the part of the opposite sex it does so rather unwillingly and under protest, as it were, and the resultant acts often lack something of their normal vigor, finish, and completeness. Especially is this true of many of the males forced to play the feminine rôle in copulation.

So far as *potentialities of kind* of behavior are concerned, the two sexes are almost on a par, and possibly we may correlate this with the fact that these birds usually exhibit but little *sex dimorphism*. As a useful device for the comprehension of this complex situation, the following conception may be suggested: There are

types of conduct distinctive of each sex; these may be termed masculine and feminine traits. Each bird possesses its own distinctive sex-traits deeply and thoroughly ingrained in its organization. These tendencies function with a high degree of readiness, ease, finish, and perfection. The organization of each bird also contains in a more or less embryonic fashion the traits of the opposite sex. These tendencies function only under unusual situations and the resultant behavior lacks the normal degree of ease, vigor, and completeness of expression. The relative strength of the two systems of tendencies varies with the individual, and we may say that male birds differ in their degree of masculinity, while the females likewise vary as to the dominance of feminine traits.

These two systems are reciprocally related to each other at many points of contact and hence are mutually exclusive in large part. They also differ as to the stimuli to which they are susceptible. Aggressiveness, vigor, and determination in demeanor and act tend to arouse the feminine traits, while submissiveness and coyness make their natural appeal to the masculine tendencies. The type of conduct manifested by any bird will thus be a function of the strength and nature of its sexual impulse and the reciprocal behavior of its mate. In a natural mating each bird will usually manifest the behavior distinctive of its sex. When the male is temporarily exhausted from his endeavors the female may take the initiative and perform the mounting. Often the sexual impulses do not develop synchronously in a pair, and thus we may have a female dominated by passion mated with a male who is in a state of relative unreadiness. In such a situation the female may make the advances and possibly assume the masculine rôle in courting and copulation. If incubation is defective in either bird, the mate will attempt to remedy the deficiency by doing double duty. Unnatural matings are thus possible with this conception. Each will attempt to act in a manner characteristic of its sex, but when the acts are mutually exclusive a contest will result and the bird with the weaker sex-traits—or with sex-traits nearest to those of the opposite sex—will be forced to play the rôle of the opposite sex. Since the degree of sexuality is an individual variant, the same bird may play a different rôle in two unnatural pairings.

MATING PREFERENCES.

The sexual activities are aroused by and are directed towards certain stimulating objects. What is the nature of these stimuli, and what are the reasons for their effectiveness? While no complete and final analysis of mating preference is possible on the basis of these notes, Dr. Whitman's work establishes a few general principles which determine sexual choice.

Previous social environment is undoubtedly one factor. As a matter of fact, pigeons normally pair with members of their own species, and this preference has generally been regarded as instinctive in character. But the data of this volume show rather conclusively that the species preferences exhibited by birds at maturity are to a large extent acquired and are functions of the social environment in which the birds were reared. We are told that young birds raised under foster-parents

of a different species are very apt to prefer a mating not with their own kind, but with a member of the species among which they have been reared. The author's phrase, "very apt to prefer," indicates that such means of social education are not always efficacious, and this fact shows that *some degree* of innate preference probably exists. Adult preferences must thus be regarded as the result of two factors, *instinct* and *experience*.

This fact that the range of stimuli to which an instinctive act is susceptible may be modified by experiences previous to the first expression of the act develops a novel and important principle of instinctive modification for the more prevalent doctrine assumes that instincts become modified only through the influence of simultaneous activities.

It is possible that previous experience is efficacious in part by removing fear and distrust or indifference and substituting therefor a more positive attitude of familiarity. There are some facts which indicate a fear and distrust of unfamiliar species. A pertinent example is described in Chapter XII. A young geopelia reared under ring-doves was placed with a young dove of its own species at the age of 7 weeks. It immediately manifested fear and terror. The second dove was reared with geopelias and found no cause for alarm in its new companion. Fear and distrust tend to prevent matings, as is evident from the account of a pair consisting of a mourning-dove and a white ring-dove (found in manuscript C 7/7). On the other hand, there is evidence that the normal attitude of some species towards members of some other different species is one of indifference. Under the topic "The Disposition to Fight," in Chapter I, it is stated that the wood-pigeons and white-faced pigeons, during the period of nesting, manifested hostility *only* towards members of their own species.

Behavior is the means of the selection or recognition of the sexes in mating. A male desirous of mating makes advances to various birds, and the outcome is determined by the response elicited. Continued hostility and indifference will in time discourage the wooer, and the search is prosecuted elsewhere. A certain type of response is essential to the mating. This preference for certain types and modes of behavior in the mate is probably based in large part upon innate conditions. The incident reported by Fulton (quoted in Chapter III) indicates that "vigor" makes its natural appeal to the female.

Behavior differentiates not only between the sexes but also between sexually responsive and sexually indifferent individuals. Although the sexual impulse probably may be stimulated to some extent by the advances of a potential mate, yet in the main it tends to develop automatically. The rise of this impulse is essential to the act of pairing. The choice of any male will thus be limited to those females whose sexual periodicity is synchronous, or comes in the course of wooing to be synchronous, with his own.

Contiguity is also a factor. The continued confinement and isolation of two birds will secure a mating when otherwise it would not occur. Confinement alone is sometimes efficacious, while at other times isolation from the sight and sound

of other birds is necessary. Even inter-species matings can be secured in this manner. Under natural conditions of freedom the selection of a mate is probably determined in large part by chance proximity at the time of sexual readiness. The contiguity secured through confinement operates in several ways. It keeps the birds together until their sexual impulses become synchronized. It tends to eliminate any possible fear and distrust. Which matings a bird will accept depends partly upon the strength of the sexual impulse. Confinement with a certain bird will thus in time overpower the usual canons of preference and secure matings which would not occur in conditions of freedom.

Selection of a mate is influenced by the *strength* or *potency* of the sexual impulse. When the impulse is weak, at the onset of its development, it responds only to the normal or adequate stimuli; when the disposition waxes strong, due to lack of expression or other causes, and the usual stimulus is absent, it overflows the normal bounds of preference and the bird may of necessity accept almost any sort of an object with which to gratify its impelling passion. As noted above, confinement will thus force matings which would not otherwise occur. Pairings between like sexes are secured in this manner. One can thus explain some of the unusual cases of sexual behavior described in Chapter III. The male becomes dominated by the rise of the sexual impulse, but his mate repels his endeavors. Stimulated by her presence and acts—working himself up into a state of frenzy by his endeavors—he finally attempts satisfaction on the young, on the seed-dish, or on another convenient object. Given an unrequited and dominant passion, what is more natural than to make advances to his own shadow on the floor or his image in a bottle?

The case of the male mourning-dove that regarded the author as his mate (Chapter III) presents some difficulty of explanation. The bird was purchased from a dealer when a few months old. It may have been reared in isolation or with pigeons of a different species. No data are given in the records. It was kept in the author's study, after its purchase while young, until sexual maturity was reached. Other mourning-doves were in the room, though no statement is made as to whether they were kept in separate cages or were reared in common. Evidently this bird received a good deal of personal attention, for it became quite tame and well acquainted. It is thus possible that this male had been reared with birds of a different species and its preferences had become fixed by this experience, so that birds of its own kind failed to attract it. Solitary and alone, but accustomed to the presence and attentions of its benefactor, its interest and attention centered upon him for companionship. The bird may have been reared, while with the dealer, in entire isolation from pigeons, and the human environment was perhaps the only one in which it lived with any degree of intimacy; and this early training may have so fixed its habits of interest and attention that they persisted for some time after being given companions of its own kind. These habits were finally broken up, and after some effort this male was induced to pair with a female of a different species.

FIDELITY OF PAIRING.

A pair of birds normally remain faithful to each other during the reproductive cycle and then maintain their relations in the succeeding cycles of the season. It has been noted, however, that the female may desert a mate defeated in fight for the stronger male. We are not definitely told whether the matings are spontaneously continued in subsequent years, but often probably they are not. This fidelity of pigeons is at once explicable on the basis of the principles developed in the previous section. One does not need to postulate an "instinct of fidelity" to account for the circumstance that pigeons act as if actuated by well-developed ethical ideals. During a reproductive cycle there is little opportunity for illicit intercourse, for the reason that the sexual impulse is suppressed during incubation, *i.e.*, it is limited to the first week of each cycle. Their reciprocal activity in courting and nest-building keeps them in proximity to each other and relatively isolated from others. At the time there is little likelihood that any other birds would be simultaneously disposed, except when such pairs are members of large flocks. At the end of the first cycle the rise of the sexual impulse will be closely synchronous in the two members of the pair, and this impulse generally develops while the pair is still kept together by the necessity of caring for the young. Fidelity is thus a necessary result of the synchronicity of impulses and the proximity to each other and the isolation from others which result from the cycle. As a matter of fact, illicit copulations with paired birds do occur; and we know further that a pairing may be broken up and a new mating be almost immediately obtained. These facts are readily explicable on the basis of the conception already developed.

FUNCTIONAL INTRA-RELATIONSHIP OF ACTIVITIES.

The various activities of the cycle are presumably woven together in some sort of a causal nexus. In the analysis of these relations we need to distinguish between the impulse or disposition, the objective sensory stimuli which excite it, and the resulting behavior. By an impulse we mean any intraorganic condition predisposing the organism to a certain line of behavior. Both the stimulus and the impulse necessary to any act may thus be a result of previous activity. The utility and validity of this distinction will be obvious from the subsequent discussion.

FEEDING.

The initial act in feeding on the part of the old birds consists of presenting the open beak to the young. The conditioning factors of this act are both internal and external. The external stimuli are an attitude of helplessness, certain cries, flapping of the wings, and the teasing contact of the beak of the young. The favorable internal condition is a full crop. The relative amount of coöperation of the two is highly variable. On the one hand, the parents may respond to vigorous and insistent appeals of the young when they have nothing to give. Again, the internal stimuli may become so strong, the desire for relief so compelling that the parents will attempt to force food upon their unwilling progeny, may return to

young which have been weaned, may make advances to adults, or they may react to bill-contact stimuli (finger-tips) which are normally totally inadequate. The range of potential stimuli is wide, and inside of this range the stimuli vary in potency. When the internal situation is weak only the most potent of the stimuli can release the response. When the impulse is sufficiently strong almost any objective stimulus will suffice. This organization is innate, and may appear in the young long before maturity, since one young bird may open the beak to the contact stimulus of another. The behavior of the young birds is likewise the expression of the internal conditions of hunger and certain objective stimuli. The range of potential stimuli is again a function of the strength of the internal situation. The regurgitating reflex is similarly the result of two independently variable factors, namely, the fullness of the crop and the contact in the rear of the buccal cavity which results from the thrust of the beak. Apparently this mechanism is somewhat similar to the vomiting reflex in the human.

The feeding activity develops from the previous activities of the cycle *in two ways*. Its adequate stimulus—the helpless birds in the nest—is an obvious product of the earlier activities. But an impulse to feed is also necessary to the act, and this impulse is *in part* an outgrowth of the previous conditions, for birds will not feed young unless they have participated in the cycle, and even then they will feed only at a certain stage in the cycle. The very last few days of incubation are quite essential to the impulse, for it will fail to develop if the birds do not persist in their incubation duties to the end. The onset of the impulse is due to the “milk-secretions” of the crop, and this is probably bound up physiologically with the previous activities in a way analogous to the mammary-gland secretions of mammals, though one must recognize that incubation and intra-uterine development are radically different situations. Although the impulse originates in prior conditions, its further development into functional potency is a result of its own activity.

INCUBATION.

Incubation is likewise dependent upon *two sets* of conditions. The sensory situation to which the bird responds is quite complex; it comprises the eggs, the young, the nest in a given environment, and the various activities of the mate. The “potency” of these factors is proved by the fact that their removal or alteration will disrupt the act at times. For examples the reader is referred to Chapter VII. The removal or breaking of one or both eggs, the death of one or both young, the failure of the young to hatch, may each produce a disruption of the cycle. The necessity of doing double duty, the sexual advances of the mate, the introduction of a new mate, sexual union, a new nest, a new position for the nest, the introduction of novel stimuli inducing fright, may each and all prevent a continuance of incubation. The *modus operandi* of many of the stimuli is ambiguous. We do not know the relative efficiency of sight and contact in the reaction to the young and the eggs. It may be that neither the sight nor contact of the young is the effective stimulus, but rather that the cessation of incubation is here due

to the stimulus of an unrelieved crop resulting from their absence. Neither can any assertions be made as to the "relative" potency of the various objective factors.

The existence of an "impulse" as an essential condition of incubation is likewise obvious. Mating birds will not incubate at all times, even though all the objective conditions are present. If the objective stimuli were the only decisive factors, incubation should persist until the young desert the nest. A pair may enter the incubation stage and then desist without any objective defect. Also, incubation may persist for the normal period when most of the objective conditions are absent. Rich food may terminate the act before its normal end, and the author has interpreted this fact to mean that the disposition to incubate finds its primary root in the "exhaustion" resulting from the previous sexual behavior and that the disposition will tend to persist until recuperation occurs. On this basis rich food will hasten recuperation and shorten the duration of the period.

The great variety of results (Chapter VII) may be explained by supposing that the various conditioning factors vary independently of each other in potency. If the disposition be "weak," the removal of any one of the objective factors will disrupt the act; when the disposition is "strong," the same objective defect will be impotent and disruption will result only from a number of deficiencies. Given an impulse at its maximum strength, incubation will persist in the absence of practically all of the objective factors.

Incubation is a result of the previous mating and nesting activities. The causal nexus is mediated in *two ways*. The previous activities furnish the objective stimuli essential to the act, viz, the mate, the eggs, and the nest in a particular environment. Likewise the disposition to sit is a physiological outgrowth of these former acts. Numerous lines of evidence may be adduced in support of this latter proposition. There is no case of a bird manifesting a disposition to sit without some indication of previous sexual activity. The male of the blond \times white ring pair (*X-W 1*) was slow in his sexual response and, as a consequence, began incubation 4 days late. All of the objective conditions essential to incubation were present, but no disposition was aroused until the usual period of sexual activity was completed. Normally the birds do not always begin incubation coincident with laying. As to the relative efficiency of the various constituents of the sexual and nesting activities in contributing to the development of the incubation impulse, no very confident assertions can be made. Probably "every phase" of these prior activities contributes somewhat to the result. Undoubtedly both the prior dispositions, as well as their behavior manifestations, are effective. On the one hand, the impulse to sit sometimes develops when the sexual and nesting impulses are denied any adequate expression, and, on the other hand, deficient expression often results in a very "tardy" development of incubation. Several pertinent facts may be mentioned. The nesting activities, in these conditions of close confinement, are, for the wild species at least, far from normal. Females may incubate without having laid eggs. Both males and females may incubate when they were forced to assume the rôle of the opposite sex in mating and nesting.

The male of the pair X-W 1 did not participate in nesting and his sexual advances were repelled, yet incubation developed in due time. A hybrid male paired with another male by mistake, courted for a month without inducing a response, and then began incubation with objective deficiencies. Inadequate sexual expression may result in delay or lack of incubation. The male hybrid cited above illustrates delay. A bronze-wing pair were separated and each remained in a state of sexual readiness for 45 days without inducing the impulse to sit. When the rise of the sexual passion is not synchronous in the two birds, the rise of incubation is timed in reference to the beginning of "sexual activity" and not with the rise of the sexual impulse.

Though incubation is a result of preceding activities, it is not an invariable result. A male mourning-dove courted and united with his mate in several cycles, but refused to participate in either nesting or incubation. A pair may mate, court, unite, and construct a nest, but proceed no further with the cycle. Other cases are mentioned in which the only defect consisted of a lack of incubation on the part of the male. We are thus forced to assume that incubation and sexual activity may vary in relative strength, even though they stand in a causal relation. Incubation results from the sexual activities, but the two impulses are not necessarily proportionate in strength. Incubation may be normal when the preceding conditions were somewhat deficient, while incubation may be weak or absent when the previous acts were normal.

Incubation and sexual activity are also *mutually exclusive* and antagonistic phenomena. The two never occur together. Coition ceases immediately as incubation begins. The rise of sexual activity during incubation disrupts the cycle, and the sex activities generally appear shortly after incubation terminates. The resultant advantage of this relation is obvious; but one can not explain the mechanism of the antagonism in terms of its consequents or advantages. Neither can the relation be explained in terms of the mutual exclusiveness of the activities *per se*; for, in the early periods of incubation, the eggs are often left uncovered for sufficient time to allow coition. The antagonism must be conceived as obtaining between the two "dispositions."

Whitman has suggested a conception (Chapter VIII) which is not wholly unsatisfactory in explaining these relations. Incubation is due to "exhaustion" resulting from the previous sexual or reproductive activity. Incubation is thus a result, and the two must necessarily be mutually exclusive impulses. Neither does it follow that the strength of the two tendencies are always proportionate, for exhaustion and recuperation could well depend in part upon factors other than the degree of sexual activity. In fact, the author regards exhaustion merely as the *primary* or *germinal* condition from which incubation arose. Other supplementary factors were added in the process of evolution before the primary condition could be utilized in the manner in which it is manifested in pigeons. Whitman would not only admit, but also assert, that the incubating behavior of pigeons is to be explained only "in part" in terms of exhaustion and recuperation.

In Chapter VIII the author gave but two proofs of his hypothesis. These were the phylogenetic history of incubation and the fact that the incubation period can be shortened by over-feeding. The conception is further supported by the phenomenon of "pumping"; the cycle is disrupted after the eggs are laid, and the birds are thus kept in a continued state of sexual activity throughout the season. Whitman (Vol. II) and later Riddle have found that this procedure develops germinal weakness, a condition which results in an increase of infertility, a greater percentage of partial embryonic developments, and an excessive proportion of females. The following quotation from Fulton (p. 35) is also apropos:

"The result is likely to be the ruin of the constitution of the hen; for if she is what is called a free breeder, or lays her eggs fast, before the season is over she becomes so weak as in many cases to become ruptured, and in other cases barren, when she is of course valueless. The cause of this is not only excessive laying—indeed a young and rank hen will often lay, like a fowl, whether she be mated or not—but the cock-bird continually driving her to nest and teasing her while in her weak state, which causes her weakness of course to increase, until the ovary gives way, and she becomes what is termed "down behind." . . . We have known some persons, by what is called 'pumping' a hen, or breeding from her as long as possible, to obtain 8 or 9 pairs of eggs from her in one season; but we have seldom known more than half reared, and often some of these would have crooked breast bones, which is a great fault as well as a sign of weakness. And as to the hen herself, she is, as already stated, if not entirely, seriously debilitated for life, so that none of her after progeny will be as vigorous as they ought to be."

There are certain features as to the division of labor in incubation that deserve comment. The impulse seems to develop rather independently in the two birds, though later there is certainly some degree of interaction. It is suggested that the impulse to sit is continuous in both birds, that each bird is desirous of sitting at all times, and in fact would do so if it were not for the need of food, the necessities of bathing and defecation, the desire for some form of alleviating activity, and the insistence of the mate in participating in these duties. This conception accounts for the fact and mechanism of interchange, and the tendency for each bird to do double duty in case of defection on the part of the mate. The female, because of her more *exhausting* sexual activities, which involve the forming and laying of eggs, is dominated by the stronger impulse, with the greater need for rest and recuperation, and as a consequence she begins earlier, stops later, and puts in much more time during the day. The early irregularity of incubation, we are told, delays the hatching of the first egg relative to the second, so that both hatch more nearly at the same time than they otherwise would. This result possesses the advantage of securing a greater equality in the feeding of the two young. The delay on the part of the male tends to secure a further advantage in that the male's activity does not interfere with his mate's duties in the matter of the laying of the second egg. In this connection we may note the fact that in *Ectopistes*, which lays but *one* egg, both birds start incubation previous to egg-laying.

NESTING.

In the nesting activities the existence of an impulse and its development from the previous sexual activities is evident. Nesting occurs only as a part of the sequence of activities, and when the impulse is satisfied the activities cease. The

acts persist when no necessity is present, for the birds are forced to choose their old and ready-made nests. The impulse to seek a new site is manifested even when there is no opportunity for gratification. This tendency to seek the site in a new locality can be correlated with the advantage accruing from the resultant weaning of the previous set of young. Both parents may be feeding at this time and the previous young may not yet be entirely weaned from the nest. If the old nest be utilized, the second cycle may be disrupted in this manner. Such an incident is reported in Chapter VII. Results, however, can not explain the existence and mechanism of the tendency. One would need to conceive this behavior somewhat in the light of a negative reaction to the old environment.

In the matter of the selection of a site, we can do little but ask a number of questions indicating the problems involved. What are the objective conditions necessary to the satisfaction of the birds? Must the seeking impulse run a certain temporal course before it can be satisfied, and is it then easily satisfied by almost any condition present at the time? Which bird takes the initiative in the selection? Must the impulse run a certain time in each bird independently of the other? The records make it probable that one bird may become satisfied with a site while the other remains undecided for some time. If they do not influence each other as to the time of choice, do they influence each other as to what the site shall be? And which of the pair exhibits the greater initiative in this regard?

Evidently the two tendencies do as a matter of fact become harmonized and adjusted to each other; little can be said, however, as to the means by which this is accomplished. Is the choice purely instinctive, or is it highly adaptive to variable conditions? To what extent may experience play a part? The impulse can adapt itself to changed conditions, as is evident from the final selection of the old site and the adoption of a ready-made nest which, in many of the species studied, is far removed from the sort of nest used under natural conditions. The nest-constructive acts are highly instinctive, being observed in a young bird when resting on the floor. It is suggested that the stimulus to these movements is the uncomfortable contact situation which the resultant acts relieve.

SEXUAL ACTIVITIES.

The nature of the objective stimuli in the sexual activities has been discussed under the topic of mating preference. A disposition is also present here, since the acts are not always manifest when the objective conditions are present. The impulse arises in part spontaneously and automatically, but it is also stimulated to some degree by the persistent advances of the mate. The stimulating influence of the mate is made evident by several instances, cited in Chapter VII, in which the male was able to disrupt the cycle and entice his mate into sexual relations within a few days. The sexual passion further develops from its own expression and from the reciprocal stimulus of the mate. Without *expression* the cycle *may* not develop further, or the sexual period *may* be greatly prolonged before incubation is aroused.

The impulses arise in the two birds somewhat independently of each other. Synchronization of the two cycles is effected in two ways. The two birds stimulate each other to some extent, and each bird will *remain* in a state of sexual readiness for some time when interaction is absent. The initiation of the subsequent stages of the cycle is timed primarily in reference to the beginning of sexual interaction rather than with the onset of the sexual impulse. This conception involves the assumption that many of the preliminary courting activities serve in part to attract, interest, and sexually excite the mate. The author is definitely of the opinion that the display activities serve this function. Necessarily the exact function of each act and the mechanism whereby the result is achieved must remain somewhat speculative. There are four possible functions of the activities: (a) to excite the sexual impulse in the mate; (b) self-excitation; (c) to arouse in the mate the attitudes and behavior necessary to coition; or, (d) to serve as motor outlets of energy incidental to the sexual act. A few speculative suggestions may be offered.

(A) The act of "billing" probably serves the first purpose. This act of taking the beak of another bird into the mouth occurs in both courting and feeding. The act *per se* is nearly, if not quite, identical in the two cases. The differences lie in the situation in which the impulse develops, the nature of the stimulus, and the functional result. In many organisms there seems to be an intimate functional relation between the sexual activities and those processes involved in the care and feeding of the young. The sexual activities and their physiological consequences stimulate and arouse the food secretions. Nursing may suppress the sexual impulse. The stimulation of the sensory regions involved in the feeding and care of the young tends to excite the sexual passion. The vigorous thrust of the beak stimulates *regurgitation* with one internal situation, but arouses *passion* when the bird is sexually disposed. Though the primary result of the act in courting is sexual excitement, yet *feeding* does occasionally occur as an incidental by-product when the internal conditions are such as to favor it. In the later stages of the cycle the primary purpose of the act is to feed the young, and likewise we might expect at this time a secondary result of sex-excitement if the conditions are at all favorable. Such conditions are not present during the first week or so, while close incubation is the rule; for, as we have seen, incubation and sexual activity are mutually exclusive functions. As incubation gradually terminates, however, this possibility exists, and as a matter of fact sexual activity frequently appears at this point. This conception of an incidental sex stimulation resulting from the feeding activities will thus explain the very general tendency toward an immediate renewal of the cycle and the *synchronous* appearance of the sexual impulses in the two birds.

The conception presented above is further supported by an observation furnished by Dr. Riddle:

"Two male blond rings had been paired and given eggs to incubate. The young were hatched and fed, and the pair were again given eggs in due time. The previous young had

left the nest, but were still being fed during the second incubation period. One of these young birds, No. 560, was observed to participate in this incubation when only 38 days old, and the activity was continued for more than a week. This act was a genuine case of incubation, as was shown in several ways. It occurred after the nest had been deserted by both of the young; the young bird took up such a position as to cover the eggs completely; and it exhibited the usual incubation behavior of ruffled feathers and an attitude of holding its ground, when the hand was placed in the nest. Further observation showed that the two old males were driving the other young bird (a nest-mate) in the attempt to wean it, but that they were, at the same time, most anxious and eager to feed No. 560, and that this feeding was almost invariably followed by attempts to mount and copulate with the young bird. This situation continued for some time, and finally the young bird was itself observed to attempt the complete sexual response; only its muscular inability to bear the weight of the male prevented any copulatory success. The first successful coition was observed when the young bird was about 3 months old. The motive to this unusual prolongation of the feeding on the part of the old males was primarily *sexual*. The young bird was at first primarily interested in the *food*, but the continuance of the activity finally aroused a sexual response before maturity. This abnormal sexual attitude of the old birds toward the young is probably a result of their unnatural sexual relation; the pair consisted of two males. Possibly the awakened sexual impulses would have found a normal outlet in a pair consisting of male and female."

(B) Some of the activities are designed to arouse the appropriate attitudes in the mate. As noted previously, each bird possesses the behavior potentialities of both sexes, and the system awakened depends upon the behavior of the mate. Driving and charging stimulates coyness and submissiveness. Hugging and "jumping over" tend to arouse the necessary stooping attitude in the female; and the movements adapted to secure sexual union are the outcome of the contact stimuli incident to the mount.

(C) The billing, preening, and pecking at certain feathers on the wings and tail seem more of the nature of a self-excitatory process. These parts are the sensory regions involved in certain reflexes incidental to mounting, and it is thus possible that the act of preening is designed to stimulate these areas and arouse the sexual inclination.

(D) The activities preceding coition are highly uniform for various species, and this fact will suggest the conception that they are adapted to secure certain results in the progression of events in the cycle. The activities immediately "subsequent" to contact, however, exhibit many specific variations, and one may therefore suspect that they serve no particular function in the cycle, but are the specific modes of expression of the neural energy released in the orgasm. When no definite result is to be achieved, variability in response may be permitted.

EGG-LAYING.

Some of the acts in egg-laying are adapted to the purpose at hand, while others are probably incidental but necessary results of the labor involved. The preliminary symptoms of ovulation are stimulated mainly by the presence of the egg, but probably in part by antecedent conditions, because these symptoms were more than once observed when no eggs were produced.¹ The stimulus to ovulation

¹ The possibility that ova were set free in the body-cavity is not excluded by the author's data.

is to be found in the *preceding* sexual activities. Fertilization is not necessary, as a pair of females may stimulate each other. When a female is stimulated by another female acting as a male there is a more frequent lack of eggs than in normal conditions. This deficiency may be due either to the lack of sperm or sperm effects or to the inadequate masculine behavior of the mate. Feminine modes of behavior constitute a favorable though not an essential condition, for the female which assumes the masculine rôle does not lay as frequently as her mate; moreover, in those cases in which she does lay, her eggs are often several days late. Contact is efficacious, but not essential. As Fulton says, "neither contact nor any of the activities of a mate are essential; a young and rank bird will occasionally lay without a mate." Undoubtedly ovulation may occur in a female that occupies a cage alone. These cases were almost certainly preceded by a rise of the sexual impulse. Probably ovulation is normally a result of all the preceding conditions, the sexual impulse, its various modes of expression, and the stimulus resulting from the behavior of the mate. The relative efficiency of these factors may be variable, and at times a deficiency in any one may prevent ovulation, while in other cases ovulation may occur when but one condition is present.

MISCELLANEOUS.

The motive to any act is an ingrained impulse or disposition toward some sensory stimulus. The bird acts as it does because it "feels" disposed to do so; it acts in harmony with its feelings and impulses of the moment. The act brings certain sensory results which are satisfying, and these results may enter into the motive subsequently. The acts also achieve other results with a biological utility; but these advantages may constitute no part of the actuating motive and bring no satisfaction to the bird. To the bird these results are mere incidental by-products, without meaning or significance. Many proofs of this conception are offered. Such activities as seeking a nesting-site in a new locality, construction of a nest, and roosting away from the nest at night are manifested under environmental conditions in which they are entirely gratuitous and unnecessary. Birds will incubate without eggs or young; or they may desert either eggs or young. In satisfying their impulse to remove the shells, the parents have been known to deposit the fledglings on the floor of the cage and leave them to perish and the young may be injured or killed in the act of feeding.

While the organization of the cycle of activities has been perfected, probably by natural selection, to achieve certain results, the adaptation need not be absolute and letter-perfect. The theory of natural selection demands only a practical perfection sufficient to secure the survival of the species in their conditions of life. Not every egg need be hatched nor every young be reared. Moreover, the utility refers only to those conditions in which the organization was developed. On this basis certain acts, which appear unutterably stupid and non-intelligent from the human point of view, are rendered more comprehensible. Although the young birds may be cast from the nest along with the shells, or seriously injured in the process of feeding, or eggs and young be heartlessly deserted, or the

nesting activities be manifested when they are useless, these consequences are insignificant from the standpoint of the birds, and they do not occur with sufficient frequency to militate against the practical utility of the bird's organization in the long run.

The instinctive organization, however, does possess a high degree of plasticity and adaptiveness at many points. Acts are adapted to meet novel conditions and the bird may persist in its duties in spite of many defects. The mating preferences are quite plastic. Natural preferences may be overcome and a bird will pair with a member of another species or with one of its own sex. Each bird may assume the duties of the opposite sex throughout the cycle whenever necessary. The old nest and site may be adopted in spite of a strong inclination to the contrary. Continuous incubation may be attempted when the mate deserts. Incubation will be continued in spite of serious defects and obstacles. Acts may be modified to some degree by experience. The effect of experience has been noted chiefly in connection with the mating preference, the preliminary symptoms of egg-laying, the preference for a nesting-site, and the removal of fear and distrust of strange birds. The effect of experience in mating has been discussed. It is remarked (Chapter VII) that the female of the passenger-ring-dove pair "will learn by experience to waste less time in fruitless formalities, and make less ado over such a small matter as laying an egg." The supposed male of "pair D" was driven from his nest and then sat for a time in an empty box. In a few hours he developed a preference for this site which was difficult to break, although the box contained no eggs and was filled with dry dung.

The author has developed what one may term an orthogenetic conception of instinctive development. Instincts are not novel and unique constructions which spring, without ancestry, into being; rather each new instinct¹ is but a slight modification or organization of tendencies already in existence. This conception is well depicted in his treatment of the phylogeny of incubation (Chapter VIII). Each of the prior elements or stages in the process of development has its own meaning and survival value. Any complicated instinct is built up by small increments; but natural selection is operative throughout, for each stage as well as the final product has a selective utility of its own. The mutation conception is thus unnecessary, and we are relieved of the difficulty of assuming a gradual or integrative development over long periods in which natural selection is powerless to operate. On this conception the same act with slight modifications may function in widely different situations, and any act may have several utilitarian results. The consequences—bringing satisfaction to the bird—may be far different from those upon which natural selection has operated. Many illustrations are given in the manuscripts. A pertinent example is the case of "billing," which occurs in both courtship and feeding. There is a marked similarity and intimacy of connection between charging and driving, display, jealousy, pugnacity, and the behavior subsequent to dismounting. For the details of these relations the reader is referred to the appropriate topics.

¹ In Chapter XIII this same principle is applied also to "intelligence."

CHAPTER X.

VOICE AND INSTINCT IN PIGEON HYBRIDIZATION AND PHYLOGENY.¹

If Professor Whitman had completed his work, he would have produced an extensive treatise on the phylogeny of the pigeon group. All of his studies would have been brought to bear upon the problems of phylogeny. The voices and the behavior of the various species would have been used, like their color-patterns, to throw light on the relationships, derivation and method of origin of pigeon species. To this end, Professor Whitman was interested in discovering similarities and differences of voice, and in learning which elements are homologous in the voices of different species.

The "Voice" manuscripts unfortunately show no approach towards the final stage of working out a complete phylogeny of the group; but this whole volume on behavior is replete with details of likenesses and differences in species, showing here and there species relationships. Many passages, unused elsewhere, but bearing especially on this problem are here gathered together. A considerable body of data on voice and instinct in hybrids contains facts relevant to the subject of species relationships; these data offer, moreover, a contribution to our knowledge of voice and instinct when these are subjected to hybridization.

Admittedly fragmentary as is some of the material at hand, it is certainly desirable to give, in this volume, as much as is possible of the presentable results of the author's studies on the topics indicated under the title of this chapter. It is not practicable to isolate the author's statements on species relationships and present them under the topic placed immediately below in this chapter. The editors have therefore diagrammatically represented the lines of descent in a very condensed form; to these figures little other material is added; the specific statements of the author must be sought in other parts of the chapter and in other chapters. The diagrams will perhaps assist the reader in visualizing those statements. It is thought that these figures,² representing as they do the lines of descent of those species most referred to in the present volume, may also prove otherwise helpful to an understanding of some of the statements of this and of other chapters. In their present form these diagrams are indeed largely reconstructions by the editors, but the manuscripts for this and other volumes leave no doubt that they approximate to an accurate representation of the author's conclusions; in most cases, however, the conclusion was not based upon voice and behavior alone, but on other evidence, wholly or in part. The second and third sections of the chapter include data on the modification of voice and instinct in hybrids; these have been divided by us on the basis of closer and wider crosses. In a final section are placed some of the more complete studies on the voice (and behavior) of some pure wild species.

¹ This chapter was compiled and edited by Dr. Wallace Craig and Dr. Oscar Riddle.

² In figure 2 the parts A and B were drawn by Wallace Craig, C by Oscar Riddle.

ON SPECIES RELATIONSHIPS IN PIGEONS.

The main stem of the pigeon branch, if I read correctly the testimony of color-patterns, is represented most nearly by the turtle-doves (*Turtur orientalis* and *Turtur turtur*) of the Old World. The original turtle-dove pattern, in which all or most of the feathers were similarly differentiated into a "dark center" and a "light edge," seems to have been a very general if not a universal avian pattern. This pattern certainly preceded the chequered type of the rock-pigeon (*C. affinis*), and it is possible still to find connecting types—types in which the turtle pattern coexists with the chequered pattern, the latter coming in to replace or supersede the former. Examples are to be seen in the bronze-winged pigeon (*Phaps chalcoptera*) of Australia, the Florida ground-dove (*Chamaepelia passerina*), and some others. (EM 1.)

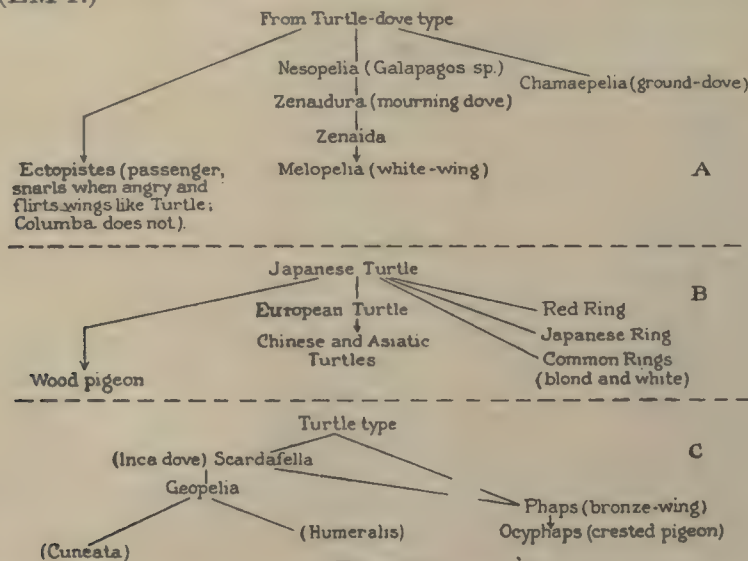


FIGURE 2.

In the above, parts A and B were drawn by Wallace Craig, part C by Oscar Riddle. Of the genus *Columba*, *C. palumbus* seems nearest to the turtle-dove. *C. fasciata* seems separate from the others. *C. rufina* is probably close to *flavirostris*. *C. squamosa* is probably higher than *C. leucocephala*. The stock-dove (*C. æna*) and the rock-dove (*C. livia*) are more closely related to each other than to the wood-pigeon (*C. palumbus*); the stock-dove probably came, not from the rock-dove, but from the same ancestor. *C. gymnophthalma* is related to *C. squamosa* and *C. leucocephala*.

One of us (W. C.) often asked the author to state his conclusions as to species relationships; he never replied at great length. The following notes, made at the time, present some of his conclusions and are worthy of record:

"The Japanese turtle-dove (*T. orientalis*) is the most nearly ancestral. From the Japanese to the Indian and thence to the European species there is a continuous transition toward smaller size. There is a similar transition in ring-doves from Japan to Europe.

"The Inca-dove is probably related to the geopelias; it lifts and spreads the tail the same way in cooing. The geopelias show in their juvenal plumage their relation to the turtle-dove. The Inca-dove is probably the lowest; *G. cuneata* is the highest; *G. humeralis* is probably a branch off by itself, but standing nearly as high as *cuneata*.

"The bronze-wings are somewhat related to the geopelias, as is shown by their behavior, but they have retained most of the turtle-dove pattern.

"There are wild species so much alike that an unpracticed observer could see no difference in appearance. Yet the voice and general behavior are very different. The specificity seems to permeate to every element of the bird's constitution.

"I think the kind of study of instinct that is much needed now is what I might call the morphogenesis of instinct. Instincts certainly did not arise suddenly; they are traceable back to simple beginnings in the lower ancestors." (Conv. '08-'10, W. C.)

VOICE AND INSTINCTS IN HYBRIDS FROM CROSSES OF SPECIES AND GENERA.

In hybrids one finds *intermediate behavior* very well marked. Voice affords a most striking illustration of the same thing. From a hybrid between two distinct species one invariably obtains notes that are intermediates of those of both parents. Sometimes the hybrid will begin with notes that are more nearly those of one parent and then break off into those more nearly those of the other parent; in other words, it will exhibit a sort of lack of coördination, a lack of equilibrium, if the term may be used there. The bird has not complete control of its organs. (SS 10.)

HYBRID BETWEEN A MALE ST. ALBA-RISORIA AND FEMALE SPIL. SURATENSIS.

The "display coo" which is given in courting, or in threatening opponents, is delivered in the manner and time of *suratensis*—i.e., in the manner of both parent species—and in a time that is quicker than that of the ring-dove and possibly a little slower than that of *suratensis*. It has a marked element of the rattling, rapid vibration which is so characteristic of the Surate turtle; but in this it stands midway between the two parent species. The male ring-dove occupies about $2\frac{1}{2}$ seconds in delivery of one display coo and passes continuously from one coo into the next.

The "nest-call" of this hybrid was timed with the following result:

- Repeated the call 19 times in one minute.
- Repeated the call 18 times in one minute.
- Repeated the call 14 times in one-half minute.
- Repeated the call 10 times in one-fourth minute.
- Repeated the call 10 times in one-half minute.

The call is three-fourths to one second in length; the interval between calls varies. Ten times in 15 seconds is the more rapid rate, with intervals averaging about one-half second. It varies all the way from one-half second to 2 seconds in the above observations, which were continued during 20 minutes.

The call is of two syllables, but these flow together; the first is about one-half the length of the second. The second syllable is a swell, but hardly rises in pitch above the first. The sound is rather loud and harsh, having the vibrations of *suratensis* roughened so as to merit the term harsh. The mode of delivery of this call is that of either parent; the bird getting into the nest-box, raising the tail, and lowering the head close to the bottom of the box.

In dropping one of the first two syllables, the hybrid makes an approach to the ring-dove. The hybrid's call varies not only, as above stated, in length and rate of repetition, but also in the quality of the tones, the relative measure of the syllables, in loudness, degree of roughness, etc. In short, the call is far less even or regular than in a pure-bred species. The nest-call of *St. risoria* is $2\frac{1}{2}$ seconds long as a rule; it may be shortened to 2 seconds.

This ring-*suratensis* hybrid mated, at the age of 22 weeks, with a female ring-dove and gave opportunity to study its "note of sexual pleasure." The ring dove has a "laughing" note after sexual union. The *Spil. suratensis* arches its neck and gives a peculiar, short note, somewhat like the danger note, but expressive of intense pleasure. The same note is given by *Spil. chinensis*, *T. turtur*, *T. orientalis*, and by my fertile hybrid from the common pigeon and the Japanese turtle-dove. The ring-*suratensis* hybrid also gives this note in a modified form.

The mother of this hybrid is now (Mar. 19) mated with a male *Spil. chinensis*. Just now I heard the sexual call of both. It is repeated several times by both—the male standing

still, the female often walking around him, back and forth, two or three times, while repeating the call. The first repetition is quite loud and fairly rings out; the later ones gradually diminish in force. This call is given with beak closed and is an orgasmic grunt, similar to the danger-note, but with far greater emphasis and delivered with great gusto.

The "perch-call" is the call in which this bird best displays the lack of fixed adjustment in its vocal organs. So much does the bird's voice vary in pitch, rhythm, quality, loudness, etc., that he often appears like a bird practicing—trying to use his organs—but unable to make two calls precisely alike. His voice-machinery seems to wobble up and down, from side to side. The voice is now hoarse, now relatively smooth, now monotone, now dissyllabic, with a strong swell on the second syllable.

The greatest variation seems to be in passing from one syllable to the next, the voice fairly rattling or gurgling at times. In all this variation, the departures are never very wide. There are two syllables, generally suggesting *coo-ooo*, in which the second is a swell more or less strong, and marked with a vibration that reminds one of that of the mother species; but the vibration here is weaker, i.e., it is less marked. Sometimes the call comes nearer *caw-aw*.

In delivering the call the bird swells out the neck so as to show its neck-spots best on the swell. It opens its mouth slightly at the beginning (inhaling), holds the head nearly still, but throws it forward and upward about one-fourth inch when it begins the call. In repeating, the head may move a little or not at all, according to the vigor of the call. If the call is loud, then the one-fourth inch movement is seen. The call is three-fourths to 1 second long. The swell is somewhat the longer part.

The "warning or fighting note" of this hybrid is given when he drives his mate or threatens another dove through the wire. The male ring-dove has a peculiar laughing note for this, to which the hybrid's note seems related. (R 14.)

MALE HYBRID BETWEEN A MALE BLOND RING AND A FEMALE JAPANESE RING.

The "nest-call" is repeated three to four times in the course of 10 seconds; each call occupies $1\frac{1}{2}$ to 2 seconds, the interval (shorter ones) is 1 second or a fraction less. The call is of two syllables or three. If not answered it may rise to four, the same as in the "perch-call." In the nest-call the first syllable is short; the second is prolonged with swell and a slight rattle or rolling sound of *r*; the third syllable is cut quite short and abrupt. The call is low in pitch, rather hoarse and growl-like.

A male *St. douraca* (Japanese ring) was kept alone in a pen in the house for a month or two so that I could compare his cooing with that of the hybrid. The pure ring gave his call at intervals of a few minutes—loud, full, clear, smooth. The hybrid's call had the same number of syllables, delivered in about the same time and inflections, but his voice was decidedly harsh and far less pleasant to hear. It was not so loud and far-going as that of the pure bird.¹

After counting and timing many instances of the perch-call or song of *St. douraca* and of the hybrid, the author came to the conclusion that the "hybrid keeps up his calls for a longer time." That is, the hybrid gives an average of 10 calls in each continuous series; *St. douraca* gives only about 8.

THE VOICE OF RING DOVES.

The "nest-call" of female blond rings is a short *coo* followed by a trill. Indicated thus: *Coo-r-r-r-r-r-r-oo*. The whole occupies about $1\frac{1}{2}$ seconds. The *coo* and the final *oo* are of about the same duration, and each occupies not over one-tenth of a second, the remainder of the time being used in the trill.

¹ That is to say, the voice of the hybrid is more hoarse than that of either parent species.—EDITOR.

When the blond ring gets frightened and is pursued it utters a "cry of terror"—a painful shriek or groan on being caught in the hand—often repeating it convulsively. Sometimes it sounds like a sobbing cry, especially if given when the bird is exhausted and is struggling to escape, but sees no escape from the hand closed upon it.

The voice of blond rings is shown in several kinds of crowing. There is the ordinary "crow" (song) which the bird makes when sitting on a perch. This crow is not accompanied by any strutting, bowing, or display of any kind. It may have served in a state of nature as a means of calling the mate when separated. It is made on the nest by both the male and female, and also on the perch during the evening, if the birds are awakened from sleep. In the latter case the crow may have the same meaning that the crow of a rooster does at night. It is an assertion of personal rights, rights of perch, nest-mate, etc. The male very often gives this crow in the daytime. Parents in this way call the young to eat.

Then there is the crow performed before the female (often before males too), which is accompanied by strutting, bowing, and display of form and plumage. This is designed to charm the female and is used in wooing a mate.

The first efforts with the voice have been noted in blond rings. I noticed that one of a pair of young—a bird 10 weeks and 4 days old—made two attempts to crow. His voice has changed enough to permit of a rude crow, which an inexperienced person would hardly recognize as such. It is the first time I have noticed such an effort. I take it as a good sign of the male sex. Another blond-ring young, only a day more than 7 weeks old, was seen to crow—with bows and display—to its mate. The voice was quite imperfect, but the manner was the same as that of the adult.

A sort of "stammering" was noted in some ring-doves. A white ring (*St. alba*) male often wakes up in the evening in my study and begins to call, but stammers for a few moments before being able to give the regular call. One of the young of this white ring stutters just like its father. A blond ring (male) in my possession also stutters in the same way. (R 27.)

VOICE AND INSTINCTS IN HYBRIDS FROM CROSSES OF FAMILIES AND SUBFAMILIES.

A MALE HYBRID BETWEEN A MALE COMMON PIGEON AND A FEMALE JAPANESE TURTLE.

When this male was 5 months old its voice was studied and the following noted: The "danger-note" is precisely like that of the common pigeon. I think both parents agree in this. The bird also solicits the female by billing the wing, as do common doves and Japanese turtles.

The voice is deep, strong, and smoother than in hybrids between the common dove and ring-dove. The "call-note" is peculiar, unlike that of any other dove, although it approaches in form that of the common dove; it differs chiefly in its rapid repetition during 15 to 20 or more seconds at a time. The call is repeated slowly at first (for 4 to 5 seconds), then quickened to about two every second. In the course of an hour I several times counted 27 to 28 calls in 15 seconds; and once 41 calls in 25 seconds.

The "nest-call," differs strongly from the call-note and is distinguished from the nest-call of common doves in being hoarse. In the "coo" the motion is up and down, somewhat like *St. risoria*. The wings are often dropped below the tail, with the quills falling apart, a little as in the ring-dove. The coo resembles that of the common pigeon, while differing strongly. When the hybrid was 6 months old it was noted that the "perch-call" was rather low and hoarse.

The "display coo" is accompanied by the up-and-down movement given somewhat as in the ring-dove. The tail is dropped down as the head rises, but I have not seen it spread and dragged on the ground, as is the case with the common pigeon. It inclines to lift the feet in cooing, sometimes alternating—one foot with one call and the other with the next.

Sometimes only one foot beats time, sometimes neither is lifted. This lifting of feet is characteristic of the mother species and turtle-doves in general (also crested pigeon and geopelias). The voice is a deep bass, very strong.

This bird is especially fond of ring-doves, and I have only to bring one to him to get him to coo at any time.¹ He is so tame that within a foot of my head he pays scarcely any attention to me, behaving just as if I were not present.

A brother to the above described hybrid has a "danger-note"—a short grunt or growl—like that of the two parent species. To-day the hybrid "cooed" three times to a ring-dove. The voice is unlike that of any other hybrid, and in quality certainly has something of the mother.

The only female² hybrid I have thus far obtained of this kind—one between a homer and a Japanese turtle-dove—was heard to give, after copulation, the peculiar note which is common to the maternal species, the Asiatic turtle, and the mourning-dove. (R 14.)

The following cases of *mixed instincts* in hybrids may be given here, though other cases have been given in previous chapters:

A hybrid between a common pigeon and a ring-dove, when first set free from a pen or when it escapes, is quite as likely to *alight in a tree*,³ if one is near, as on the roof of a house. This has often been tested in Woods Hole and in Chicago. The hybrid takes to a tree like a ring-dove; the latter shows a decided preference for the tree, and generally at mid-day seeks one in which to rest, even though it must go farther for the tree than for a house.

The ring-dove prefers "night quarters" on the outside, even in the rain, to going in. The same is true of the crested pigeon and others. The dove-cote pigeon seeks shelter early—by sunset or before. This hybrid prefers to go inside at night, but is slower to retire. I have four hybrids free, and some dozen dove-cote pigeons also free; the hybrids are always the last to retire. In other words, these hybrids are less strongly inclined to seek shelter at night. The same is seen in stormy weather, when the hybrids, like the ring-doves, usually remain outside, while the dove-cote pigeons prefer shelter and usually go in.

Why does one prefer shelter from rain and for the night, while the other prefers to remain in the open, refusing to remain inside, however many times it may be driven in? Probably the dove-cote pigeon actually "feels" safer in a cot at night, and finds the shelter from wind agreeable, while the ring-dove is so constituted that it "feels" more comfortable in the open than in the cot. It certainly shows repugnance to the cot or a shed. How is this difference brought about? Originally all prefer the open; the dove-cote pigeon has been trained to "dove-cot," and individuals that keep to cot are safest and therefore protected.⁴ (R 14.)

HYBRID BETWEEN A MALE ZENAUDURA CAROLINENSIS AND A FEMALE ST. RISORIA.

This male hybrid calls in the nest-box to a female *Zenaidura* which has just been placed in the adjoining pen. The tail is raised about the same as in either parent species; but it is not spread at all with the call, at least not in this specimen. It is usually, though not always, spread in the mourning-dove. The tails of both are vibrated about the same as in the ring-dove.

The "nest-call" is repeated quite regularly once in 5 seconds, now and then a little short of 5 seconds, so that 1 or 2 seconds may be gained in the course of 6 or 7 calls; at

¹ The records show that this hybrid was hatched and reared by ring-doves. (O. R.)

² The hybrids obtained from *family* crosses were practically all males. (O. R.)

³ This refers to the well-known fact that the dove-cote pigeon and the rock-dove shun trees, alighting on the ground, on rocks, or on houses. (W. C.)

⁴ Cf. Darwin's view that the dove-cote pigeon must have come from a wild ancestor, such as *C. livia*, which lived in caves and not in trees. (Animals and Plants under Domest., Vol. I.)

other times, in a little over 5 seconds. Each call is a full second long; it consists of two syllables, which flow together so evenly that they seem like one monotone at a distance of a few yards. The first syllable is a short *coo*, and the second is most nearly the sound of *oo* in *coo*, but prolonged in a swell that rises slightly in pitch above the initial sound, falling at the end. The two syllables flow together without any break. The tone is a little rough, but is fairly smooth in some individuals. It is a rather loud call—louder than that of the mourning-dove, and not so pleasant. Heard in the house, at a distance of one floor (below), it sounds like a moan of some one in distress. It is something more mournful than the notes of the mourning-dove.

The nest-call of *Zenaidura* is the same dissyllable, in which the two syllables are plainly distinct, even at any distance in the house. The first part is longer proportionately than in the hybrid, and the second part is a smoother and more marked swell.

In one count, the "perch-call" was repeated 17 times in 20 seconds, and in quite even time. Frequently the call is repeated about once per second. This prolonged repetition (which occurs also in the *Ectopistes* × *risoria* hybrid) does not come from the father (see perch-call of *Zenaidura* below). It is probable that it comes mostly or wholly from the mother, since *St. risoria* repeats its perch-call in rapid succession. The call is more distinctly of two syllables, and a little higher in pitch as well as smoother and more agreeable, than the nest-call. The same letters, *coo-oo*, may be used to express this call, although it is quite different in quality of tone and manner of delivery from the nest-call. The bird stands in normal pose—head up and tail drooping naturally.

Another of these male hybrids exercises his perch-call very freely. His voice is quite full and smooth and far-reaching, telephonic. He repeats the call sometimes as many as 15 times in about 15 seconds; sometimes only 5, 7, or more times, averaging nearly 1 call a second, the calls following one another in continuous strain. The pause between the strains may be only a few seconds, or 15, 30, or longer. But the strains are heard frequently in the morning hours, between dawn and 9 to 10 o'clock, and then again towards evening.

One of these hybrids gives the call in a loud monotone in which two syllables are hardly recognizable. It sounds like blowing over the lip of a bottle-neck, and reminds me of the call I have heard from the Wonga Wonga pigeon (*Leucosarcia*). But the call of the latter is very much less loud and is softer.

In sexual union the male hybrid shakes his feathers—like the male *Zenaidura*, but not so persistently or so vigorously—as a means of getting the attention of his mate when he is about to offer his bill. He opens his bill to receive that of his mate, and seems prone to repeat this several times before mounting. In case the female offers herself he frequently declines, again offering his bill, so as to excite her more before mounting. When he mounts he hurries, executes the act very quickly, in the manner so characteristic of *Zenaidura*. *St. risoria* acts decidedly slower.

After copulation, when the male has resumed his place beside his mate, he arches his neck and gives a short grunt, the "note of sexual pleasure," which is not quite so loud as in *Zenaidura*. It is the note so characteristic of the turtle-doves, and the note which is also given by the wood-pigeon (*C. palumbus*). This bird has refused to mate with ring-doves, either white or blond; but he is very eager to mate with a female *Zenaidura* as soon as I put her near him. Other of these hybrids prefer ring-doves.

Both mourning-doves and these hybrids, when walking about on the floor of their pen, or when on the perch, give the tail an upward toss now and then. I noticed that this motion is not made when flying up and alighting, as it is in *Spil. tigrina*, but always (?) in correlation with a head-movement; *i.e.*, if the bird is looking at you—and from fear, excitement, or what not, gives its head the peculiar back-and-forward motion—it is almost sure to follow it with a toss of the tail, this toss carrying the tail 1, 2, or 2.5 inches high.

One of these hybrids escaped from its pen early one morning, before feeding. It flew into a large willow close by, where it remained, flying about occasionally from branch to branch, until about 9^h 30^m a. m., when it came down into the yard. Finding its own pen, it tried to get in. I opened one of the pens, and soon it went in and was captured. The early return was prompted by need of food and by the semidomestic instincts of its ring-dove mother. Its flight was rapid, and the movement of the wings and the marking of the tail made it look like a true mourning-dove.¹ (R 14.)

HYBRID BETWEEN A MALE ECTOPISTES AND A FEMALE RING-DOVE.

The "nest-call" is a sort of "caw" resembling that of the male parent, but very much weaker. The tail is held up and slightly spread, and the head bowed, as he looks at the female. In the "note of attack" the bird bristles, drops the head, shortens the neck, and gives a scolding or snarling note. This is given when he flies at another dove, or when he jumps to peek through the wire netting of his pen. He often flies up to the side of his pen against another bird, and while the other bird merely tries to peck, making no noise, this male always emits his snarl. This snarl is like that of the male parent, but the hybrid gives it with markedly less vigor and shrillness than it is given by the parent.

This hybrid has the up-and-down motion of a ring-dove, to accompany its "coo," but not so pronounced as in the latter. Its "coo" is the same "caw" repeated several times with the up-and-down motion. It solicits the female by offering the open beak, as a ring-dove does (I have never seen *Ectopistes* do this); but it slurs this part and more often omits it entirely. Often before offering the beak the hybrid bills his wing as the rings and common doves nearly always do, and as *Ectopistes* occasionally does.

These hybrids have thus far shown a decided mating preference for female ring-doves over every other species. They give little attention to female passengers. A hybrid brought into the house in January at once became amorous at sight of a female ring-dove. So eager was he that he pursued her in spite of her strokes—not offering to resist, but simply facing the blows, spreading his tail, and jumping like a male ring-dove.

The "call-note" is a "caw" emitted from 5 to 10 or more times in slow succession. The bird sits fairly erect on the perch, with the body, head, and tail inclined a little. The beak is very slightly nodded at each caw. This call-note in *Ectopistes* is usually emitted *once* at a time, and it differs very much from the shriller and louder note of attack or threat. I do not now understand how it comes to pass that the hybrid emits its call so many times in succession. Possibly this is a peculiarity from the ring-dove mother. The ring-dove repeats its coo or call (5 to 15 times) when calling on the perch, and takes the same position. This would be a curious mixture of instincts. The ring-dove often repeats the call 15 or more times.

Two of my passenger hybrids have *weak voices*; they are barely able to make the call-note audible. They make the same call in the same way, or attempt to do so, but their vocal organs are too weak or ill-constructed to enable them to vocalize strongly. (R 14.)

INSTINCTS IN ECTOPISTES RING-DOVE HYBRIDS.

I placed a pan with earth and earthworms in a pen containing 4 hybrids and 2 adult ring-doves. The four hybrids with their ages and designations, were as follows: *D* 2, 8 weeks less 1 day old; *F* 2, 5 weeks less 2 days old; *G* 1, 4 weeks plus 2 days old; *G* 2, 4 weeks plus 2 days old.

¹ See voice of mourning-dove in the following section. If the reader will also further compare this account of the voice and behavior of the hybrid with my account of the behavior of the two parent species, he will be able to form a better idea of the relation between the behavior of the hybrid and that of its parents. (W. C.) (See Craig, W., 1909. The Expressions of Emotion in the Pigeons. I. The Blond Ring-dove, Journ. Comp. Neurol. and Psychol., vol. 19, pp. 29-80, and 1911. The Expressions of Emotion in the Pigeons. II. The Mourning-Dove, The Auk, vol. 28, pp. 398-407.)

The oldest hybrid (*D 2*) pecked at some worms lying in sight and tried them several times in his beak as if to test them. Coming to a worm which was nearly buried, and which contracted quickly on being seized, the bird became more eager, and with one or two pulls drew it from its burrow. The bird picked it up several times, dropping it after testing it in end of the beak; it then picked up the worm, taking it farther into its beak as if to swallow it, but again dropped it. At the next trial the worm was swallowed. The same bird soon after swallowed two other worms, and without many trials. *F 2* tried the worms over and over, but did not swallow them. *G 2* swallowed one, after many trials with its beak. *G 1* was in a nest-box at the time, and so did not participate.

The male ring-dove walked back and forth over the pan, but never once stopped to touch a worm. (I later saw a worm eaten by one of my ring-doves.)

Here, then, is a case where the instinct, received from the father, acts independently of imitation. The bird's instinct led it to be attracted by the worm at first sight, and the wriggling of the worm stimulated the bird to snatch it quickly from its burrow, just as the adult *Ectopistes* does.¹ The birds had never before tasted of worms, having been bred under ring-doves and having received only seed and bread.

One of these hybrids escaped from a pen and was not seen for 4 days. At the end of 4 days it came back, and after staying about all the afternoon, it tried to get back into its own pen. I opened the door a few inches and it walked in at once. The wild parent would never have returned; its ring-dove parent would probably have returned. The hybrid has the "home instinct" from its mother, and has it certainly in a higher degree than the father.

The passenger-pigeon, when captured, emits a cry of distress or terror, and struggles hard to escape. If it finds its struggles of no avail, it will soon stop and often *lie motionless* in the hand, *feigning dead*, for some moments after the hand is open. It will lie for nearly a minute on a shelf if left undisturbed. It is a mode of playing dead. The passenger hybrid also emits a shriek on being caught, struggles, and at length remains motionless, as if dead. Its action is therefore like that of the paternal species. This trick may be played by almost any dove, but is more marked in the passenger and its hybrid. (R 14.)

VOICE AND BEHAVIOR IN CERTAIN WILD SPECIES.

VOICE AND SEXUAL BEHAVIOR OF ECTOPISTES.²

An adult male ring-dove (*C*) and an *Ectopistes* (*I A*) young, a little over 3 weeks old, were allowed to go free in my library. Both were sitting on top of the pens. *C* began to walk towards *I A*, with a view to driving him off. The latter seeing him coming, emitted at intervals a simple sound, much like a low, mild cluck of a sitting hen. This note is quite different from the scolding note when the bird threatens to attack.

A few minutes later *C* again approached rather slowly and without show of hostility. *I A* gave one cluck, lowering his head, and then emitted the single call which the male gives when calling his mate to nest. This cluck is the "danger-note," or at any rate indistinguishable from it. A little later this same day I heard the danger-note emitted when a bird was seen flying in the distance. Another passenger (*I B*) only 4 weeks old, while sitting on his perch, was approached by a ring-dove. The young pecked at the intruder, and in doing so gave an audible puff of air from its beak, quite the same as one hears in the young domestic pigeon when it is approached by anything strange to it (*e.g.*, a hand). The young *Ectopistes* (*I B*) has not been heard to squeal for some time, but it has not yet,

¹ A case of a young passenger (4 weeks, 4 days old) eating earthworms is cited under "Food Instincts," Chapter XII. It is stated that ring-doves eat earthworms "when they have young to feed."—EDITOR.

² For more than one reason it seems desirable to preserve these records on the voice and behavior of the now extinct passenger-pigeon.—EDITOR.

at 7 weeks old, given the squawk or cluck, although daily under provocation at feeding and roosting. At the age of 8 weeks I heard it give the danger-note or cluck, but it was not the finished note.

A male passenger (*I A*), 2 years and 7 months old, is in a large pen with a female *Ectopistes*. This male has just been separated for two days from a white ring-dove.¹ He does not court the female of his species, but sits at a corner of his pen, where he can see some ring-doves in cages about 10 feet away, and calls to them. He sets his feathers in best order, and puts on a most charming expression as he eyes them. His "call" consists of two very distinct parts: (1) A loud, shrill, piercing squawk,² in uttering which the bird draws back its head and as its beak opens expels all its breath in one effort. Just as the cry is made the wings are flirled upward and forward. The whole performance is precisely the same as the threatening-note. The movements of the wings in this case are a means of attracting attention; while in the threatening mood it appears to be a threat to strike or to fly at the intruder. This loud cry, with wing-flirting, is adopted in calling a bird at some distance, and it is usually followed after a few seconds with a second note. (2) This second part is a single guttural sound, or a sort of awkward "coo," in the making of which the bird raises its head, lengthens its neck, and swells the upper part of it, as if the air were forced into this part without being allowed to escape. Until this morning I never quite caught the manner of the calling. Everything to-day was favorable to seeing and understanding the sequence.

The "behavior in uniting" in the passenger-pigeon is as follows: The female, if disposed, often takes the initiative, giving the call and then hugging the male while she presses with her body against him. He returns the call and the hugging and the billing. He reaches over, so that the front of his neck bears on the back of her neck or the top of her head, and often jerks or pulls her head towards him by means of his beak, which is held like a hook over her head. He may often mount several times before the female is ready. When she is ready she stoops and raises both wings to support him. Sometimes she begins to stoop only after he has mounted, gradually and slowly lowering her body to a horizontal position. The male expects her to raise her tail to contact with his; if she does not at once do this he touches her head with his beak, with a single stroke first on one side then on the other, or touches her beak near the base, as if to make her lower her head and raise her tail. It is more probable, however, that he does this to excite her to the point of responding to his movements. The pressure of the body and neck against the female is to induce her to active participation in the act. The pull with the beak hooked over the head and the side stroke of the beak, as well as the fondling of the head feathers, all tend to excitement, and they are the expression of the sexual impulse.

I have never seen the female put her beak within that of the male, an act so common to other pigeons. The male crested pigeon, as well as the passenger, has often been seen to peck gently the head of the female after mounting, to induce her to raise the tail and lower the head.

A male *Ectopistes*, when standing at a distance of a foot or two from the female, will often emit a loud squawk and rush towards her, and hug her with surprising vigor. When he practices this on another species to whom it is unfamiliar he frightens the bird he would court. I have had a female *Ectopistes* mated with a satinette (*C. domestica* var.) all winter and spring. She had often offered herself in the usual way for her species, but the satinette took the passenger's action to be an attack, and though he usually retreated, he sometimes seized her and shook her. It does not seem as if they would ever understand each other. He is always too gallant to press against her. (R 25.)

¹ Since a fledgling he had spent various periods with ring-doves.—EDITOR.

² This "squawk" is what I have named the "keck." (See Craig, W., 1911. The Expressions of Emotion in the Pigeons. III. The Passenger Pigeon (*Ectopistes migratorius* Linn.) The Auk, vol. 28, 1900, 408-427). (W. C.)

VOICE OF THE MOURNING-DOVE (*ZENAIIDURA CAROLINENSIS*).

The male has a low "love-grunt," which he gives when he comes up to the female, or flies to her, in the breeding-season. It is a little greeting given as he struts up to or around his mate.¹

The author gives a record of the time occupied by 144 "perch-calls" (song or coo) of the mourning-dove, in order to show the contrast with other species and with *Zenaidura* hybrids. This record shows that the perch-calls were given in "strains" or series, varying in length from a series of two calls lasting a fraction of a minute to a series of 34 calls lasting 10 minutes. The interval of time from the beginning of one call to the beginning of the next averages about 15 seconds and is never less than about 12 seconds. This rate is strikingly unlike that of the *Zenaidura* × *risoria* hybrid.

The mourning-dove loses its voice towards the end of August and never tries to coo; or if it is sometimes moved to try, it gives a most ridiculous note, as if its organs of voice were out of tune or as if it had forgotten how to do it. If these doves are kept in the house during October they will, after molting is over, reacquire the full voice in the course of a few weeks. Some males mated with ring-doves were placed in pens in my library on Oct. 1. After a week or two I noticed that they began to try their voices. At first the efforts were feeble and repeated only once or a few times a day. The efforts gradually increased until the bird had a full and penetrating voice, and their calls were then repeated so often and with so much vigor that it often became annoying. This loss and return of voice with the breeding-season is of general occurrence among wild migratory birds that breed only in the summer season; for example, in the cuckoo.² (R 34.).

VOICE OF ZENAIDA.

A *Z. vinaceo-rufa*, which had recently lost his mate, gave his "perch-song," or "distance call." This call consists of four coos, as does also the "driving-call" given in 3½ seconds. I have never heard it repeated in long strains, as happens in some other pigeons. The syllables (coos) are of nearly equal length, pitch, volume, quality, etc. The call is very low, as compared with that of the mourning-dove, and is delivered so quietly that it frequently escapes attention, even at a distance of only a few yards. The male's "nest-call" is a low, single, abrupt, hoarse muffled note—a *cuh* cut short and barely audible.

In calling a female to the nest a male lowered his head, raised his tail and rump feathers, spread the tail somewhat with each call, and gently vibrated one or both wings, according to occasion. He was very slow in his movements and took great care not to approach the female, as if he wished to avoid giving her the least alarm. He would jump into the nest-box when she alighted on it and quietly try to win her to his side. His eyes then beamed with delight; he would very quietly change his position and move his wings to invite her closer. If she hesitated he would quietly walk away, fly to the perch, and upon alighting would strike the perch or nest-box two or three times quickly with his feet. This striking, done mostly when the female is at a distance on the floor, seems to be a quiet way of attracting attention. The same is done by the mourning-dove.

The call to the young to be fed (call to feed, or "feed-call," as it may be named) is, so far as I can see, exactly the same as the perch-song. The voice of *Zenaida* is, then, a simpler form than that of *Zenaidura*; but it is easy to see that the mourning-dove has a

¹ This is evidently the homologue of the "kah" used as a greeting by *Turtur* and *Streptopelia*. In *Zenaidura* it is so greatly reduced that I never heard it myself.—W. C.)

² It is much to be regretted that the circumstances of the preparation of this volume have precluded references to Prof. F. H. Herrick's studies on instinct and behavior in birds; included in those studies is a very able presentation of the behavior of the cuckoo. (O. R.)

voice modified from the *Zenaida* type of four similar, smooth, even syllables.¹ The first two syllables in *Zenaidura* are together equal to the first in *Zenaida* and they are continuous. I think, therefore, they should be counted as one from the point of view of their origin.

A female *Zenaida amabilis* (?) seems to give a "nest-call" (heard twice so far) that resembles the first syllable (a short initial note followed by a slurred rise in pitch) of the perch-call or song of the male mourning-dove, although it is not so strong. The sound is decidedly similar to that of the mourning-dove in quality and inflection. This bird is higher then in voice and in white bar of wing than *Z. vinaceo-rufa*. (R 2.)

VOICE AND BEHAVIOR OF THE WHITE-WINGED PIGEON (*MELOPELIA LEUCOPTERA*).

A dozen of the white-wings were kept in the house during the winter. Matings began about the first of January, but with no very serious efforts to nest. About the middle of January 2 or 3 pairs were mated, and these pairs became pugnacious and savage towards the others, almost killing one of them. I then removed from the pen all except 2 pairs; these can probably remain in the same pen, as they have already claimed nest-boxes in opposite corners of the pen. It is interesting to see ownership of nest-territory develop and the disposition to drive away every intruder. The behavior is rather remarkable in this species, as the bird makes demonstrations of its temper with voice, bristling feathers, and especially by peculiar jerks of its tail. To its mate it turns with the utmost fondness and gentleness, even while showing its spiteful scolding and threatening twitches of the tail to an outsider.

When another bird approaches, both sexes manifest their displeasure by jerking the tail up and down—spreading it more or less—and with spiteful quickness with each upward toss. At the same time the bird "bristles up" so to speak, erecting especially the mid-dorsal (interscapular) feathers, so as to give itself a larger and more formidable appearance. It seems to be consciously striving to look as big and fierce as possible, in order to strike terror into the transgressor. The warlike attitude, the fierce look, the erect feathers, the vicious flashy jerks of the tail are reinforced by a spiteful "note of warning." This note I am unable to describe satisfactorily. It is a querulous, fretful snarl, designed to warn off the intruder. If the threat is not heeded, the bird follows it up with a jump toward the offender—a bluff to try its courage. If it retreats the bird dashes boldly after it; if it stands its ground the wings are raised and the birds approach and settle the matter by blows.

When this warning-note or snarl is emitted the beak is slightly opened, so that one can see between the mandibles. I am not sure that the note is to warn. If other birds are in the neighborhood it is uttered frequently as the bird moves about. It may be merely an expression of the fretful state of mind excited by the sight of an intruder. The note is certainly an element in the behavior of the bird, and it fits well with all the other elements which are plainly of a warning nature. The note may be of a similar nature to the note of the Japanese turtle, which is given as the bird strikes at another with its beak. The white-faced pigeon (*Leucosarcia*) raises its tail, lowers the head, and gives a peculiar sound when it threatens to attack. The bleeding-heart pigeon (*Phlogœnas*) takes a similar attitude and gives a similar warning noise before attacking, from which I conclude as to the relationship of these genera.

The "general call" or "coo" is often heard after dark in the early evening, as I learned when these birds were in a large outdoor pen. Both sexes give this call, but the females

¹ The attitude of *Zenaida* in uttering this call is essentially the same as that of *Zenaidura*. The bird stands stiffly still with the neck somewhat arched; there is no movement, except that with each coo the crop swells out greatly and the feathers all round the neck are somewhat raised. The general behavior, the attitudes, and gestures of *Zenaida* are much as in *Zenaidura*; for example, the habit of jerking the head, the "nod," consisting of a backward jerk of the head followed by an upward jerk of the tail, with the tail coming slowly down again. (W. C.)

coo with less fullness, more awkwardly, and more as if it were a lost art with them. The coo of the male is often quite melodious and flute-like in timbre.

The "nest-call" of the male is of 5 syllables—3 in the first half and 2 in the second half. It is very hard to describe this. It often sounds like a low barking—an individual growl (first syllable) followed by the first two barks (second and third syllables), emitted in connection with rising emphasis on the second bark; then follows a closing part—two barks in close connection and with falling inflection, with the final bark somewhat prolonged. The whole call is accurately measured in each syllable, so that there is a certain kind of melody, or at least rhythmic regularity, in the call. The first syllable is really the initial vocalization—a sort of start necessary to the emission of the succeeding notes—flowing directly into the two dissyllables, into which the call proper is divided. The call proper, then, can be said to consist of two distinct parts, each of which is composed of two syllables, and these are preceded by an initial note which serves to set up the regular rhythm.¹

With the first half of the nest-call the male commonly momentarily raises both wings, slightly spreading them as he spreads his upraised tail. The effect of his white wing-marks and of the white bar of the tail is thus made quite striking. I notice that when the female is out of sight this lifting of the wings is often omitted, and that when the female approaches the nest the male at once shows all his colors. *There is then an evident desire to display to the female.* (R 31.)

SUMMARY.

The turtle-doves of the Old World (*T. orientalis* and *T. turtur*) are considered the nearest of the living species to the ancestral dove or pigeon. Pigeons belonging to families different from the turtle-doves are noted as having one or another degree of the elements of the voice and the behavior of the turtle-dove. It is only in these comparisons, however, that any considerable description of the voice or behavior of the Japanese and European turtle-doves is given. The degree or order of relationship to the turtle-doves, of the species most referred to in this volume, is figured in condensed form at the beginning of the chapter.

In hybridization, the voice and instincts of the parents are blended in the hybrid, the latter possessing voice and behavior intermediate to those of the parental species. Numerous examples are given. They are to be found in the descriptions of all the hybrids, from the close and from the wide crosses. The data of the manuscripts do not, however, consider the second generation of hybrids. It is an open question, therefore, whether the elements of voice and behavior blend or segregate there. It seems to be a rule that the voices of hybrids are less smooth—more hoarse and less coördinated than those of pure-breds. The description of nearly every hybrid considered refers to this fact.

Various features of the pigeon voice and behavior, as exhibited in the different species or groups, are homologized; in some cases conclusions are drawn as to the lower and higher members of a group; and additional descriptions of the voice and behavior of a number of species are given.

¹ The "voice" of the bronze-wing (*Phaps*) is given in considerable detail in Chapters II, V, and VI. The material was thus divided and used because of its relation to topics in those chapters.—EDITOR.

CHAPTER XI.

THE HOMING INSTINCT.

Besides the material given in this chapter, several of the author's manuscripts contain quotations and digests, with running comments thereon, from the writings of Reynaud, Wood, Moore, Mills, Wallace, Kobelt, Gatke, Weismann, Gourand, Jacobi, and Palmen, on the migration, orientation, and homing instinct of birds. These comments are hardly of such a nature as to warrant their utilization. In addition there are a few rough outline notes of the author's, and the following list of animals under the title of "cases of migration": (1) herring, shad, white-fish, salmon, eels; (2) fishes, toads, *Amblystoma*, turtles, seals (Lemming); (3) *a*, Stork; *b*, swallow, robin, flicker, larger woodpecker of Europe; *c*, homer-carriers, turtle-dove, wood-pigeon, *Ectopistes*, mourning-dove; *d*, ducks, geese, terns, gulls, eider-duck (Weismann); (4) Grasshopper (locusts), ants, caterpillars (Loeb), *Nereis*. It is apparent from this list, and the accompanying notes and comment, that the author contemplated an extended study of the phylogeny of migration and homing, similar to his phylogenetic treatment of the incubation instinct as given in Chapter VIII. For a further study of this subject the above list is helpfully suggestive.

GENERAL PRINCIPLES.

A discussion of the "homing instinct" is perhaps not without its value.¹ People are inclined to believe that there is something mysterious in regard to the homing instinct in the birds, perhaps a "sixth sense," a "sense of direction," or something of that sort. The way to find out whether a homer pigeon has any unusual instinct or unusual sense, is, of course, to make a test of the case, and this is very easily done.

In considering such tests, let us suppose that some homers have been kept in a pen, with no opportunity to fly about and see the country, and that this lack of opportunity has extended from the time they were hatched up to an age of a few months or a year; and that these homers were then let out into a small yard—a yard as extensive as a large room. One would think that a bird might find its way in a yard of that size, even if it had not been there before, particularly if it had always been looking out into such a yard from its smaller pen. I have repeatedly made experiments of this kind, and have found that the behavior of the birds is, in all cases, practically the same. They never seem to know what to do when they get out into this small yard. They are in a new world. The only world they know anything about is the small pen on the side of the yard. They had looked out upon this main yard daily, for months, but they have never traveled around it nor used their wings in getting from one pen to another; they have used their wings only in the small cage. The moment you let them out they smooth down their feathers and act as though they were afraid. Every step is taken with caution. They look around to see what everything means before they venture to feel that it is safe to go over it; they step around on the ground very, very cautiously indeed, and act as though they were in a new world.

¹ Stenographic notes (corrected and edited) on a lecture delivered at Woods Hole, Aug. 10, 1906. The questions of the audience and their answers have been, in so far as this was possible, incorporated into the text.—EDITOR.

If the birds thus released happen to be an old pair, with young or eggs to look after, they naturally want to attend to these at the regular times. Let us suppose that we now deal with a bird that wants to get back to its cage—a male at 10 o'clock, the time the male usually goes to the nest. At that time he will show an uneasiness and will try to find his nest; he will try by flying up to get to it, but will not know the right way to go. So he will fly hither and thither to many places, and it will sometimes seem a matter of accident if he happens to get to the right door. As soon as he gets to the right door, where he can readily see what he has been familiar with, he will go to his nest as quickly as possible and take his position.

My conclusion, from all that I have seen in the case of pigeons, is that they have no means of finding their homes excepting their *wings* and *eyesight* and *experience*. Eyesight and experience are the principal things. Pigeons have very, very sharp eyesight. Anyone who has watched pigeons in the yard has noticed how quickly they see a hawk in the air. They are always far quicker than I am in that respect, and even I can always tell when a hawk is around by the behavior of the pigeons; they are looking in the direction of the hawk, and I often find that the hawk is so high up that it is difficult to see; in fact, I may have to hunt around for it. The pigeons see it immediately, and if there are many of them about, they all seem to see it at the same time. There is no hesitation in the matter.

We may consider for a moment the method used in training homing pigeons. As you know, they are allowed their freedom and they are birds that like to fly about. They take high flights and long flights, they become acquainted with the country round about. They evidently recognize the mountains and the houses and know these houses one from another, just as well as we know individuals. Then, for training, such birds are taken a certain number of miles from home and have no difficulty in finding their way back. The next time they are taken in the *same direction* a number of miles farther. They have had a good deal of experience on the first trip, having circled round and round and taken in everything. They have good memories, and when you take them 10 miles farther they really catch the landmarks that they have seen before, and also become acquainted with landmarks in other directions; so that in this way their acquaintance with the country, far and near, is extended. The next time they are taken farther away in the same direction, and the birds are thus gradually trained, trained in the country, directions, etc. It is evidently this sort of experience that they depend upon in finding the way home.

I may give you an instance of a bird's memory. I had a pair of homers that I took from Chicago to Woods Hole, Massachusetts, and left them there during the winter. The next year I took them back. In the year of their absence I had moved my residence some 7 or 8 blocks from the home where these birds had spent several years. In taking them back to Chicago I took them to the new home. I kept them for some time in the basement of my home, since the pens were not ready to receive them; a little later, probably some time in January, I finally put them in a cot in the barn. Here they went to work and made a nest, laid their eggs, and started incubation. I thought it would then be quite safe to let them out; so I opened the cot and the birds were permitted to come out. The two birds stayed on the cot stand for a few seconds, took a few looks in different directions, and then, of a sudden, they both started and went straight down to the old home, 7 or 8 blocks away; and they did not return. They left their eggs, although they wanted to take care of those eggs as much as any parent birds would care for that. I went down to the old home and found them on the top of the house. The pens that they used to live in had all been destroyed and there was nothing except the house for them to recognize as their home. A few days later I managed to get the male bird down and into a cage. I may note that I left these birds for two or three days before I undertook to capture them again. The female was lost, was perhaps killed by a cat. But I succeeded, as noted above, in getting the male down into the cage. I put some seed into his cage, and after some time gave him

another female that was ready to mate. He accepted her and they went to work. He was then put into the same dove-cote as before. This time he apparently decided it was best to stay and he did not go back to his old home again.

On several different summers I have taken my birds from Chicago to Woods Hole, and I find those that have been to the latter place before have no trouble whatever in remembering where they were previously located; that is, whether on the west side of the barn or on the east side, or the south or north. The dove-cote holes are in different places and it is very curious to watch a bird and see him go straight back to his old home; even the manner of flying down from the roof of the house to his cot is simply a repetition of what he has done hundreds of times before. He takes the proper precaution, if his mate is out of sight, comes down and alights on the dove-stand, just as perfectly as he did it a year before. I am inclined to think these birds have as good a memory as we have.

The question of the relation of inheritance to behavior may next be briefly considered. In the first place, it may be said that the behavior of pigeons is inherited just as much as anything else is inherited; and, with the proper qualifications, the same may be said for the behavior of the homing pigeons. I should not, of course, claim that the pigeon inherits "the want to find its way"; it inherits "the way to learn." The young bird in the nest is a homer from the beginning. He sits in the nest and has a home-like air. Let him be taken away, only a little away, and he is frightened and wants to get back. As soon as he gets into the nest he feels at home. Very soon after they get their feathers the young birds begin to get out of the nest. First of all, they get to the ends of the cot where they live—just experimenting; but if any noise is made, anything that startles them, you see them hustling back to the boxes in which they have lived. In the same way they learn their way out of the dove-cote. They look out of the window first and then they venture to step out on the platform and sit there a second or two the first time; the second time they are less fearful, sit longer, shake their wings, etc., and then get back. Perhaps the next day they sit longer, and after 2 or 3 days they venture to fly down. They see the old birds and recognize them on the stand, and are afforded a pretty good chance of finding their way back in that way. Usually they are pretty careful not to get more than a few feet away. They really learn every step of their way. The homing instinct is something that is perfectly natural to them. (SS 10.)

On this topic the editor appends the following quotation from Fulton (*op. cit.* pp. 438-40):

"It has been frequently and vigorously contended that the birds "home"—as it is termed—by instinct pure and simple; also, that instinct has nothing to do with their power of homing at all, but that the sight alone enables them to reach their lofts. Various other theories have been started, as that they will only fly to the north; but the true theory doubtless is that it is partly instinct and, partly sight, intelligence, and memory. I say *partly* instinct advisedly, though probably many on reading thus far only would be ready to combat the idea. The mainspring of the resolute action of the homing bird in endeavoring to reach its home is, no doubt, the natural love of home, which is shared in by all the homing pigeons, and this I term instinct. As far as one can tell by careful observation, *every* homing bird, when thrown, endeavors to find its home at first. It stretches its neck as it flies round—or even if it pitches on some neighboring roof—in its apparent endeavor to ascertain which direction it ought to make for. This, which is developed in every bird, surely may properly be called instinct.

"It is the same with dogs, cats, horses, cattle. It is, in fact on record that a race was once carried out with cats, which were taken away from their homes and let loose; with dogs it is an everyday occurrence. And it is well known that cattle, when escaped from a field—at a distance from home—will often beat about, until at last they walk into the homestead. But though this instinct may cause all the birds thrown at one time and place to endeavor to reach their respective homes, it does not enable them all to attain success. When they have started—and done their best to find out which way to go—instinct seems to have run its course.

"All these birds, then, having probably—as I contend—the same instinct, have used it for the same purpose, and to the same end. But now come upon the scene other forces, namely, memory, intelligence, and observation. These enable a bird to remember the localities in which it has been flown before, to recognize landmarks it has noticed previously, and which are now pointed out to it by an intelligent observation of the country beneath it. Thus it is seen that though all may start fair, as it were, at first, still those endowed with the more retentive memory, the greatest intelligence, and the most accurate power of observation will, *ceteris paribus*, come home first. The instinct, then—being naturally present to a certain given extent—forms a basis upon which man can work; and the materials to be used in the work are the memory, intelligence, and power of observation. These must be educated, improved, perfected by man's labour and toil, in order to obtain a first-class bird. What one has to do, then, in training, is to give the birds a good knowledge of locality by repeated and ever-increasing trials, which will try the endurance of the bird as well as bring its gifts to perfection, and in doing so the greatest care is needed. . . .

"Having selected the birds one wishes to train, they must be taken out in a box or basket to be thrown the first time. The distance should not be more than 500 or 600 yards, and the time morning, as early as you like. The birds should be hungry, not voracious, but just nicely hungry, so that when home they may come into the loft to feed at once. A nice, clear, tolerably still day should be selected for each throw when commencing to train, if possible, in order to give the young birds every advantage. They may then be taken the next day, or as soon as convenient, but the sooner the better, to the same distance, in another direction, and so on until they have been sent in four, or at least three, directions around their home. This done, the distance may be doubled, and again sent to the four points of the compass. They will next be taken a mile or a mile and half in each direction, and by this time will have a pretty general acquaintance with the country immediately adjacent to their home in all directions. . . .

"The Belgian method of training is pretty much the same as described above, except that the stages are, after fifty miles, exceedingly severe, the birds being sent fifty, a hundred, and even more miles at a single stage, but the losses among these birds are likewise proportionately heavy in bad weather. Some of the best lofts in Belgium have been fearfully depopulated at a single stage."

ILLUSTRATIVE MATERIAL.

MEMORY.

Under the title of "Memory," the editor finds an account of seven pairs of birds that had lived at Woods Hole, Massachusetts, and at the author's former home in Chicago. On returning from Woods Hole in the autumn of 1901, these birds were taken to a new Chicago home, at a distance of several blocks from their former home. In the following spring they were allowed to nest, and they were given their freedom while incubating eggs. The account describes their behavior in these novel surroundings. These records constitute in large part the basis for the preceding discussion of the homing instinct.

By way of further introduction, the editor may note that memory for home was shown by pairs which were carried back and forth between Chicago and Woods Hole. The oldest pair of common pigeons knew their cots, both at Woods Hole and in Chicago, and never got lost or confused. They seemed quite at home when let out in either place, although, for a few minutes, they showed that they had not forgotten the place from which they were last moved. Other pairs, let out for the first time, got lost, confused, and were often unable to find their nest within a small yard.

(1) A pair of homers was taken from my former home in Chicago to Woods Hole, in June 1900, and left there until October 1901. They were returned to my new home in Chicago, and kept in a pen in the back yard, where they nested. They had young about 10 days old when I removed them to a cot newly prepared in the barn. After keeping them and their young shut up in the cot for two days, I opened the cot and let them out on the morning of the third day. I saw both birds come out soon; within one-half of a

minute they started off in the direction of their former home (during winters), which was about 5 blocks away. They did not return, but went off for good, not even coming back to the young. The next day I found the male sitting contentedly on the barn of a neighbor, close to our (former) back yard, where he formerly had his pen. The pens had all been removed, so he had only the buildings with which to locate his home. I did not see his mate, but think she may have been near by. This pair had then been away from their old winter home for fully 1 year and 7 months. Nevertheless they (or he) still knew his home, after all the dove-cotes and pens had been removed. This is a decided proof of memory of home and its environment. This homer is at least 6 years old, possibly 7 years.

On Jan. 14, 1902, I took two cages to our former home. In one of these cages was a female homer; in the other I placed a dish of seed. The cages were placed in the back yard, and the escaped male soon came down and went into the open cage for the seed, and was easily captured and returned. There is no mistake about identity; the bird could be recognized among a hundred, by his size, shape, and evident age, as well as by his behavior. When returned to his deserted cot he felt at once at home and began to coo. This male was placed in the same cot from which it had flown away, and shut in.

Five days later this male homer was placed with a young female homer (hatched in 1901) that was ready to mate. The mating was immediate, and two eggs were laid on Feb. 6 and 8. On Feb. 10, at noon, when the male was sitting, I opened the cot. The female had never been free and she came out only very cautiously, first stretching out the neck and putting her head out just enough to see the other birds flying about. Finally, she came out trembling, and stepping as if possessed with fear. She saw other doves above her on the stands, and soon ventured to fly up to one of the stands. *She did not once look back into her own hole before she left her stand*, so she is not likely to recognize it easily. She is now (1^h 40^m p.m.) on the roof of the barn, and has taken no flight. At 3 p.m. she found her way to her own stand and her mate came out, and then she followed him in. She took the nest and he came out again. The male went out and in three times within 2 minutes. The fourth time he flew to another stand, went in and fought with its inmates, claiming it as his own, until I drove him out. He flew to the roof of the barn, to the top of the court, to the top of the pens beneath his stand, walked about, and took one short circle around the barn and pens. His behavior is quite different from what it was when let out with his former mate. Now he has a new mate, a new cot, and a new nest of eggs, and he is wholly intent in caring for them, having no desire to fly away. At 3^h 30^m, seeking for his cot, he flew to a stand above him and rushed in the hole as if it were his own, and battled with the owners until I parted them and put him back in his own cot, where he remained without coming out. The two cots are exactly alike, so that it is not strange that he made the mistake of claiming the wrong place. He remained in the rest of the day, not coming out. At this season of the year all the dove-cote pigeons return to the cot by 4 p.m., or even earlier if they are not hungry or thirsty.

On the second day (Feb. 11) both birds were out and in their cot and perfectly contented. The male tried once during the morning to take possession of the cot above him, and had to be taken out and replaced in his own place. Since then he has remained at home.

(2) A second pair of homers were hatched on Apr. 26 and Mar. 26, 1900, at our former home. They are the offspring of the pair whose conduct has already been described. They were placed in a cot in the barn (Jan. 6, 1902), and here laid an egg on Jan. 13. Just before the second egg was expected, on the 15th at about 12^h 30^m p.m., I opened the door of the cot. Both birds soon came out on the stand and looked cautiously about; soon the male flew down to the roof of the pens, about 4 feet below, and the female soon followed, flying *heavily*, as birds do when carrying an egg soon to be laid. The birds then soon flew up to the roof of the barn, and after running about as if to find their nest—but shyly, as if realizing that they were not on familiar ground—they flew off, the female behind the male, across the street to the house on the south. The male soon started back with the female

after him; they stopped on my house, where they saw my male frill-back. They took three flights away, the second time about 2 blocks away, and the third time they escaped from sight, but returned after about 30 minutes. It was then 4 p.m. They searched about to find their nest, but in vain. The female sat down on the roof of the pens, and I caught her without difficulty and placed her in a cage on the ground. The male came to her, was caught, and both were replaced in the cot; the female at once took the nest. I left the cot open, and the next morning the male came out about 7 o'clock and after a few minutes went in. He did this three times in the course of a half hour, and then seemed to be content, remaining inside on the nest; meanwhile the female walked about, or sat still on the perch in the cot, not once coming out, although she once came to the door and looked out. At 10^h 30^m a. m., both were inside the cot, and apparently contented.

Evidently this pair (kept at our former home, during the winter of 1901) did not discover their old winter home, and were not so keenly oriented as the older birds. Still, had the female been unimpeded by the egg she carried, the birds might have discovered the old home. The return to my present home was insured by their having walked about and seen the premises before they first flew away, and probably by their seeing my frill-back. One return made the next more probable. The birds have not yet learned to find their cot; but will probably do so in the course of to-day, the third day after their first egg was laid.

(3) A third pair, which consisted of two frill-backs, hatched in the spring of 1901, had been kept in pens from the time they could fly, in Chicago and in Woods Hole. I placed them in a cot in the barn at my later Chicago home on Jan. 14, 1902. Two days later, at about 1 p.m., I opened the door of the cot. The birds soon came out, but did not act as shy or as keenly sensitive to strangeness of the place as did the homers. They were awkward in flight, somewhat like young birds that have just begun to fly. The important point is that they appeared to have no memory of a home elsewhere, and they made *no sign of a desire to find a lost home*, not making a single attempt to fly away or to circle about in search. After being out for a couple of hours *they did try to find a cot*, and the male succeeded, after looking for some time on the wrong side of the barn, by seeing another frill-back with a cot next to his fly to his stand. He merely followed, but was driven off by the other frill-back, and so did not really discover the way to his cot, although he recognized it after landing on the stand. After being driven off, he went back to his mate on the south side of the barn. Both birds soon flew to the stands on the south side of the barn, and I caught the female and returned her to her cot (about 3^h 30^m p.m.), where she remained without venturing out again for the day. The male, in his search for her, soon flew to his own stand, after trying several others, and once there, he saw his mate through the window, and then soon found his way through the hole into his cot. He then began cooing and strutting and appeared fully satisfied and even delighted with his home. Since the first day they have held possession.

Here we see an absence of any *memory* of home. The birds know no home but a pen. Coming near a pen, they seemed to regard it as a place they know, but they did not try to reach it. This species is a fully domesticated one, and probably they would never have a liking for a particular home equal to that of homers.

(4) A pair of red-chequered homers, bought in the spring of 1901, were kept confined in a pen at our former home, until I took them to Woods Hole, at the end of June. They were returned to Chicago to our new home in October 1901. They were kept in a pen in the basement until Jan. 8, 1902, when I placed them in a cot, in the barn, on the "south side." On Jan. 14 the female laid the first egg; the second was laid 2 days later. Two days still later, at 3 p.m., I opened the cot; the female was sitting, and the male was off the nest. He soon took the nest without coming out. She came out to the stand at 3^h 30^m, paused a minute or two, looking, and stretching once, and then went in without flying. She came out on the stand again at 3^h 35^m, went in again without flying, after looking for a moment,

but at once came out again, and soon flew down to the roof of the pens (2 feet below). At 3^h 49^m she flew up to the top of the barn. A male homer—of another pair—was the only dove out at the time. At 3^h 50^m, she flew down to the court, just as her mate was driving the other homer off his stand. Her mate went to his nest at 3^h 55^m, the female having flown to the stand above him. At 3^h 56^m she came down again on the roof of the pens. At 3^h 58^m she flew to the highest stand on the "east side" of the barn. At 4 she again flew to the roof of the barn, and in a moment came down to the court on the south side. At 4^h 01^m she was on the stand above her own. At 4^h 11^m, she went to the rear shed, thence to her own stand, and in at once.

These birds have no memory of a home in Chicago, and their memory of their home in Woods Hole does not suffice to send them flying at any distance. The nest is now a strong attraction, and perhaps they are themselves more like highly domesticated pigeons, which have less love for a particular home.

(5) I allowed a pair of black barbs to go free at our former home, took them to Woods Hole at the end of June, and brought the male and two young back to our new home in October. The female died at Woods Hole. One young was black, the other was gray with two black bars. The black one turned out to be a female, and she mated with her sire. I placed the pair in a cot on the south side of the barn on Jan. 16, 1902. Three days later I opened the cot at 10^h 30^m a.m. *The birds had no eggs.* The female came out on the stand at 10^h 40^m. She looked shy, stretched her neck, but went back in a few moments, the male remaining within. She came out again at 10^h 44^m, but went back after one or two looks. Then the male came out at 10^h 44^m, but went back after one or two looks. Then the male came out at 10^h 45^m, and was soon followed by the female. He went in at 10^h 46^m and immediately came out again and flew down to the roof of the rear pens at 10^h 47^m, and then to the roof of the barn, flapping his wings for exercise. He then came down to the court and the female flew to him. At 10^h 48^m both were on the roof of the barn, the female following the male; at 10^h 50^m both were on the court and walked to the rear roof of the pens, the male leading. At 10^h 51^m he flew to his stand, and was followed by the female after a moment. He went in, came out, then went in, and was followed this time by the female. Both came out again at 10^h 54^m, the male flying down to the roof of the pens, being followed by the female.

Both seem contented, but the female, never before free, seems very timid, while the male walks with assurance, but as if examining his new environment. At 10^h 57^m, both flew to an adjoining barn, and came back to the north-side roof of my barn. The female always hesitates to alight on a new place, stopping a moment or two before venturing to touch her feet. At 11^h 30^m they flew away, but soon came back to the barn, where they sat for the remainder of the forenoon. I found them both on their own stand at 1 p.m. and apparently fully contented.

(6) A pair of homers was allowed their freedom at our former home during the years 1900 and 1901, and at Woods Hole during July and August 1901. The pair was returned to our new home at the end of August 1901, and kept in an outside pen until Jan. 8, 1902. Eggs were laid in a cot on Jan. 18 and 20. This was opened at 10^h 30^m a.m., on Jan. 22. The male remained on the nest. The female came out again, and in course of an hour flew from the barn to the house and back in company with the other birds. At 11^h 30^m she is on a stand on the east end of the barn and shows every sign of contentment. Evidently, if birds have a nest with eggs and only one comes out at a time, there is little danger of their going away.

(7) Another pair of homers had been free, both at Woods Hole and at our former Chicago home. They were placed in a cot in a barn at our new home on Jan. 19, 1902. Eggs were laid on Feb. 3 and 5. The cot was opened at 3^h 15^m p.m. on Feb. 12, on the ninth day of incubation. The male was on the nest and the female came out and flew around and went back to the cot at 3^h 40^m p.m. The male then came out and twice got into the wrong

cot and had to be returned to his own home. On the day following he failed to find his cot and was thus prevented from sitting during the middle of the day. Again, on the next day, he became lost and did not return until 4 p. m. (R 9.)

ORIENTATION.

A pair of black common pigeons were put in a cot in the barn on May 1, 1907. They were fastened in until they made a nest and laid eggs (May 5). About 10 days later I put up a small wire cage (2 feet by 15 inches by 18 inches high) on the shelf to their cot, and so placed that its open door was close to the cot-hole. The birds could go in and out of this wire cage at pleasure. Of course, when out of this cage, they could become acquainted with the yard, the rear of the house, the dove-pens, and their neighbors in the adjoining cots to right and left, above and below. Their cot was in the second tier from below. On the evening of June 3, after dark, I removed the cage, leaving free egress from their cot.

At 5 o'clock the next morning it was dark and rainy, and these common pigeons had not left the cot. The male was on the young; the female soon came out and walked inquisitively about, as if missing the cage. Soon she came down and fed on the ground with the other pigeons, to which I had thrown seed. After a time she felt like returning, but flew to the roof of the barn, and appeared wholly at sea, although her cot was but 10 or 12 feet below. She tried several shelves, and in the course of 30 minutes reached her own shelf, by mere accident. She was not then sure of her place, but, peering into the hole, she saw her mate and went in. Soon afterward the male came out and, after behaving as if in a strange place, flew to the roof. Later the female came out and flew to the yard for food; the mate recognized her and followed. After eating and walking about the yard, she flew up and tried to find her cot. She succeeded only after blundering a little less than in the first instance. The male followed her up, but went to the roof, and found his way back about 11 a. m. Then both birds came out together, spent a half hour in the yard, and then flew to the roof of the house and to the barn. About 4 p. m. I found both in the cot above them and to the north. They fought for this cot, but at length were beaten off. After some more searching they found their cot and remained with it. At 5^h 35^m p. m. the female came out and flew down to feed. After 10 or 15 minutes she returned, going straight to her shelf. The cage made these birds somewhat at home in the yard, so that they *did not start off on long flights*; but they still could not steer to a cot, and were as if in a world from which no lines to their cot had ever been impressed upon their brains. The essentials for finding home were not there, and they were slowly and blunderingly discovered by accidental hits, which they were impelled to make by the need of relief from their stock of food for their young. (R 10.)

HOME INSTINCT.

The following records are found in several manuscripts under the title of "Home Instinct." They refer to the conduct of birds in confinement that were given their freedom or that had succeeded in escaping from their pens.

All my geopelias seem to be fairly sure not to go away when they escape singly. What they would do if two got out at the same time I do not know. But when one alone escapes, it always returns in search of its companions, and I have succeeded in recapturing them in every case. The social instinct is strong with them, and I believe this instinct is the foundation of the home instinct; that is, given the social instinct, the home instinct would inevitably follow, natural selection aiding its development.

One of my crested pigeons got away at Woods Hole and never returned. Whether the social instinct in this species would enable one to let the bird have its freedom safely I do not know. I think it might in case the bird was very tame.

One of my mourning-doves, which was mated with a ring-dove, got out of its cage; it stayed near for a short time, cooing for its mate. Soon it flew off and did not return. I

believe this dove could easily be trained to come home. I have a very tame one which escaped and flew back to my hand. Another escaped and could not be found for some hours, but was then discovered trying to get back into its pen.

A beautiful hybrid between a male homer and a Japanese turtle (*Turtur orientalis*) escaped and was gone for two whole days before it returned. When it came back I was standing in the yard. It flew down to the pens and at once recognized its own pen from others and tried to get in. It was evidently hungry. I opened a pen door and soon drove it in and captured it.

A hybrid between a male passenger and a ring-dove escaped from its pen. It flew at once into a tree. Soon after, it started on a straight, swift flight away from home and was quickly out of sight. I never expected to see it again. About noon of the same day it was found sitting over one of the pens and was captured. This return could not have been due to the instincts of the paternal species, for the wild pigeon would never return. Another similar hybrid returned after an absence of 4 days.¹

A male mourning-dove from California, which had been kept in confinement for two years, escaped from the pen in Woods Hole on July 2. He stayed about the pens and roosted near his own pen. Some one tried to capture him after dark and failed. It flew off and was not seen for 5 days. On July 8 he came into the yard and fed with the other doves on the ground. I allowed him his freedom for two days, during which time he remained about the yard, and then again captured him and put him in a pen. I think the bird would have remained with me, if nothing had happened to drive him away. The same bird escaped again on July 24. I caught him at night when he was on the ground beside a pen, and put him in the shed, leaving him to go free when the door was opened the next morning. He loitered about a pen in which another male mourning-dove was kept and fancied he had found a mate. Probably he might fly away were there no other mourning-doves about to coo and thus attract him. As it is, he stays by all day.

One of my white-winged pigeons (*Melopelia leucoptera*) escaped and flew into the willow behind the house. It was about 4 o'clock. She sat there in the same place until 5^h 30^m, then flew over the pen to a tree behind a neighbor's house. About 6 o'clock she again flew, but passed over the pens and up over the roof of a large house a block away. I never expected to see the bird again. In about 5 minutes the bird was found trying to get into the pen from which it escaped. She tried in vain, and finally took a position for the night in the outer door, where a pane of glass had been broken. There was an inner door which prevented her going further. After dark I went up and captured her. The bird had been kept in the house all winter and had been in the outside pen only about 2 weeks.

Four *Zenaida vinaceo-rufa* escaped on Sept. 9. One of these was an old bird, and 3 were birds hatched during the summer and had finished or nearly finished the first molt. They escaped from a pen in which I had 17 zenaidas and hybrids. The rest of the flock was isolated in an adjoining pen, and the feed-door of their own pen was left open in the hope they would enter. One was caught on Sept. 11, after it had entered a small cage to get seed left there to entice it. One was caught in a small cage on Sept. 15, after being out for 6 days. Two Japanese turtle × European turtle hybrids escaped at the same time. One of these was seen the next day, but up until Sept. 17, I have not seen either again. One naked-eyed pigeon (*Columba guinea*?) escaped at the same time. It returned the same day, walked into the barn, and was easily captured.

A female ring-dove which had just left its nest—about 8 a.m.—to the male was allowed to come out of its pen in the back yard. I opened wide the door, thinking that as the bird had a nest and as she was due to lay a second egg that morning she would not go away. She flew to the ground, and after a minute or so up into the large willow; after a few minutes she flew to an adjoining house, soon returned to the willow, but a few minutes later flew over the same adjoining house and was not seen again. This same pair had had their free-

dom during all of the summer at Woods Hole and had never lost their home. In the present case it was evident that the female lost her bearings and did not know how to find her nest. This seems strange, as the other doves were cooing loud. She was in haste to get back to her nest when she flew out of sight. This shows that one must proceed very carefully in liberating these birds in a city, where all the houses are so much alike that the bird can not distinguish. Once out of sight of the nest the bird is lost. If she is let out when she is young she will be more cautious, and if the male is with her he will help her to find her way back. Had I taken care to teach this bird to find her nest once or twice, she would then have got on all right.

It is an interesting fact that these ring-doves, though they may become extremely tame, yet do not seem to have any decided "home instinct." If a blond ring is let out of its cage it is very likely to fly off at random, taking no note of the place it has left, and it is unable to find its way back, though it tries to do so. As partly indicated above, however, the situation can be so arranged that it will return. If its cage is opened near the ground, and there are not many buildings which would mislead it, it will walk around and come back, especially if it has young or eggs. At Woods Hole I have mated these with dove-cote pigeons, have allowed them to go entirely free, and have not lost one of them.

I have found, however, that though many adult ring-doves, let loose for the first time, fly away and are unable to return, yet this is not true of all of them. The young birds certainly can be managed better. I have allowed 3 young rings to go free during a whole summer, and they stayed around the house and at night even went into the shed where their parents were kept in cages. Perhaps they would not have thus gone inside if their parents had been outside. The young of the domestic pigeon sticks close to his home when allowed its freedom. In its first flights it keeps its home in sight, and returns to, or near to, the spot it left. (R 6, A 1/1, R 17.)

LACK OF INTELLIGENCE.

It is astonishing how easily the common pigeon may fail to find its home (cot) even under favorable circumstances, and when the field of search is limited to a space not over 20 by 30 feet. I placed a pair of pigeons in a cot about 10 feet from the ground, behind the house, keeping them there for several days until they had built a nest and the female was about ready to lay. Yesterday, at about 4 p. m., I allowed the male to come out while the female sat on the nest. He flew out upon the pens, which were about 15 feet distant and on a level with his cot. He was very restless, as he at once discovered that his mate was not with him; he eagerly searched for her and did not seem to have the slightest idea of her precise location. He walked back and forth hurriedly over the pens, looking now and then anxiously down toward the inclosed pigeons to see if his mate was among them. Not finding her in the yard, and becoming greatly agitated at her absence, he at length started to fly out of the yard. At that moment another dove, from a cot higher up, started to fly with him. He was alarmed and flew as if a hawk was behind him, but circled round, flying across the yard and over into the back stairway of a house about 50 feet away; here I caught him and then returned him to his cot. The next day I allowed both doves to come out in the middle of the day. It soon began to shower. The two birds remained in the yard on the top of the pens until about 3 p. m., when they began a search for shelter. The female was the first to begin this search. She limited her efforts to different parts of the yard (20 by 30 feet), and herein showed that *she knew that her home was near by*. There her cot was—in open plain sight—just below, on the outside of the porch. She had no idea where to look for it. She ran about looking everywhere except in the right direction. Once only did she even fly over to it, alighting, not on the stand, but on the roof of the cot. She soon flew back to the top of the pens. After about an hour's search she flew to the stand and immediately went in to her nest. The male saw her go in and motioned as if to follow, but hesitated to fly and soon settled down as if forgetting her. Soon after (4 o'clock) he began

searching for his cot, for it was time to be on his perch. Several times he stopped, looked towards the cot, but then renewed his aimless and stupid search around the pens of the yard. This time he did not venture to fly out of the yard. After a half-hour spent in vain, he finally flew to the stand and at once recognized his home and went in.

I think old doves are, in some respects, worse off than young doves in the matter of finding home. The young are afraid to fly much, and hence go out on the stand for several days before venturing to leave it. When they do fly from it they alight in the nearest place, and seldom get out of sight of the old ones. Moreover, the old birds fly back and forth to the cot, and thus teach the young just what to do to find home.¹ The young follow the parents to their home. When this has been done once or twice, they have learned the lesson and can depend upon themselves. Old doves, on the contrary, when set free for the first time in a new place—which they know only as seen from a window of the cot—are liable to fly more freely and then be utterly unable to find their way back. I have lost several doves in this way. (R 7.)

SUMMARY.

True to his phylogenetic conception of instinct, the author regards the capacity of homing pigeons as but an unusual development of tendencies and power possessed by all pigeons. In the subsequent chapter this view is more explicitly stated as to the instincts of tumbling and pouting.² As a consequence, the observations are not limited to homers, but concern the attempts of any pigeon to return to its cot or nest. In a sense, homing is also an aspect of migration, a phenomenon which is rather widely distributed throughout the animal world, and the author was evidently considering a study of homing in the light of its wider genetic relations. This discussion is not to be regarded as a final treatment of the phenomenon; it is to be considered as the formulation of a tentative hypothesis useful for further study.

One must distinguish between the motivating "impulses" in homing and the "means" by which these impulses are gratified. There is no unique and single homing impulse. The return to home may be motivated by any one of several impulses. A home is particular only as a definite place or position; the concept is complex from the side of satisfaction obtained. A home may mean food, safety, companions, mate, nest and young, or a place to roost. An impulse or motive is a tendency to act in response to a present sensory stimulus. An act is not motivated by its sensory consequences. A bird removed from home does not respond to a home stimulus, nor does it seek a return because of the resultant satisfaction. The bird reacts negatively to the present situation rather than

¹ In the matter of leading the young, the common pigeon is a good bird to watch. When the young first comes out of the cot, its first trip to the ground is often made by falling off the edge of the shelf. But however it gets to the ground, it of course knows very little about the way back again. The parent flies down to the young one and no doubt helps it to find the way. This is especially true of the male, because the female is likely to be in the cot laying or about to lay; the female, however, also helps the young sometimes. When the male is trying to get the young one up to the cot, the young bird is of course much confused by the new situation and the strange birds around it; but the father feeds it a little and thus keeps up acquaintance with it, and then flies up to the cot. When it is time for the young to go to roost the father will fly back and forth, back and forth, between it and the cot, perhaps feeding it a little each time. He shows great solicitude until the young are safely inside. The parents show this solicitude especially the first time the young are out of the cot. (Conv. 7/10, W. C.)

² In this connection it is well to note that all fancy pigeons, such as homers, tumblers, and pouters, are not true species, but are strains or varieties developed by the breeding art of the pigeon fancier. This would indicate that these special characters are but improvements on traits and tendencies already present. The wild species *Columba livia* is commonly supposed to be the progenitor of all domestic varieties. *Columba livia* is a gregarious species, a fact which is interesting in connection with the author's suggestion that the "social instinct is the foundation of the home instinct."

positively to the home environment. The motivating stimulus is hunger, not food; loneliness, not companionship; fear, not safety, etc. Most of these motives are suggested by the author.

The social or gregarious instinct is considered of prime importance. The author indicates that a bird with gregarious habits is more likely to return than one in whom the social instinct is less well developed; a single bird will return when a pair or group will not.

Hunger is also a motive. Homers are trained when hungry, according to Fulton; and Whitman asserts that hunger was responsible for the return of some of his escaped birds. Obviously hunger could not operate with wild birds capable of finding sustenance in the open. It would apply only to domestic and semi-domestic breeds which have been accustomed to obtain their food in a certain locality and which find difficulty in living a life of freedom.

Wildness is a factor. Wild pigeons rarely return to the cot when they escape. Semi-domesticated birds may return if they have been tamed. In a sense, the failure of wild pigeons to return is a case of homing, for these birds seek and return to an environment which they instinctively prefer. They react against confinement and too close proximity to man.

Fear of unfamiliar surroundings induces return to a familiar environment where experience has justified a reasonable degree of safety. Homers manifest fear and caution when first released. A young bird taken a short distance from the nest is frightened and seeks to get back. The parents assist the young in making its first returns. When exploring, the young hustle for the nest whenever startled.

The impulse to incubate or to feed the young may instigate returns. These impulses arise at definite times, and a free bird may manifest perfect contentment away from the nest until the onset of these internal stimuli. The reader will recognize that in many cases the notes offer insufficient proof of the efficacy of these motives.

Since these impulses are avoiding reactions toward the environment, and not positive responses to the home situation, they do not furnish the means or mechanism of homing. The motive may be present and yet the bird may fail dismally in the attempt. The mechanism, according to the author, is "eyesight" and "experience." The bird can "home" because it has learned a system of positive responses toward the visual aspects of the environment. Placed in a new situation, the bird must wander aimlessly until by accident a familiar situation is reached. The influence of experience in this capacity is rather well attested by the observations on the young in leaving the nest, by the experiments on adult homers when freed for the first time, and by the methods of training homing pigeons. The influence of vision in the reaction is an assumption without adequate factual support so far as the notes are concerned. If this view is correct, two facts are significant—the readiness and ease with which these position habits are acquired and the strength with which they are retained for considerable periods of time. However, it is well to note that all behavior studies reveal the fundamental importance of position habits in the life of animals.

CHAPTER XII.

OTHER INSTINCTS.

This chapter for the most part consists of miscellaneous observations of various traits and behavior tendencies of pigeons, with some account of specific differences. The significance and genetic relations of these characters are not discussed as a rule. The topics are those of the author, but similar observations from various manuscripts have been brought together by the editor. Unity and coherence of treatment has proved difficult of attainment with some of these materials. The topics have been grouped by the editor under the general heading of "Instinct" for the sake of convenience; one may well question the applicability of this term to some of the acts described. The first part of the first topic treated is a reprint of a paper by the author, published in 1899 in Woods Hole Biological Lectures.¹

TUMBLING AND POUTING.

The evidence adduced to show that habit may pass into instinct can not here be examined in detail. Romanes brings forward two cases—the instincts of *tumbling* and *pouting* in pigeons—which he declares are alone sufficient to demonstrate the theory. We may, therefore, take these as fair examples of the argument generally appealed to.

After quoting Darwin's remarks on this subject, Romanes adds:

"This case of the tumblers and pouters is singularly interesting and very apposite to the proposition before us; for not only are the actions utterly useless to the animals themselves, but they have now become so ingrained into their psychology as to have become severally distinctive of different breeds, and so not distinguishable from true instincts. This extension of an hereditary and useless habit into a distinction of race or type is most important in the present connection. *If these cases stood alone, they would be enough to show that useless habits may become hereditary*, and this to an extent which renders them indistinguishable from true instincts."²

Granting that we have here true instincts—and I do not doubt that—what proof have we that they originated in habits? Did there pre-exist in the ancestors of these breeds organized instinct bases, which, through the fancier's art of selective breeding, were gradually strengthened until they attained the development which now characterizes the tumblers and pouters? Or was there no such basis to start with, but only a new mode of behavior, accidentally acquired by some one or more individuals, and then perpetuated by transmission to their offspring and further developed by artificial selection? The original action in either species is called a "habit," and this so-called habit must have been inherited; *ergo*, habit can become instinct. Obviously, argument of that kind can have weight only with those who overlook the test-point, namely, the real nature and origin of the initial action.

If the instinct had its inception in a true habit, *i.e.*, in an action reduced to habit by repetition in the individual, and not determined in any already existing hereditary activity, is it at all credible that it could have been transmitted from parent to progeny? Does not our general experience contradict such an assumption in the most positive manner? But may not the habit have originated a great many times, and by repetition in successive generations, gradually have become "stereotyped into a permanent instinct"? To suppose

¹ Republished by courtesy of Messrs. Ginn & Co., Boston.

² Mental Evolution in Animals, p. 189.

that such *utterly useless* action originated a great many times without compelling conditions or any organic predisposition is not at all admissible.

Darwin saw at once from the nature of the actions that they could not have been taught, but "*must have appeared naturally*, though probably afterwards vastly improved by the continued selection of those birds which showed the strongest *propensity*." Darwin, then, postulates as to the foundation of each instinct a "*propensity*"—something given in the constitution. That view of the matter is in entire accord with the theory adopted in the case of "*neuter insects*" and quite incompatible with the habit theory.

THE INSTINCT OF POUTING.

I believe the case is much stronger than Darwin suspected, and that it shows, not the genesis of instinct from habit, but from a preëxisting congenital basis. Such a basis of the pouting instinct exists in every dove-cote pigeon, and is already an organized instinct, differing from the instinct displayed in the typical pouter only in degree. I could show that the instinct is widely spread, if not universal, among pigeons. It will suffice here to call attention to the instinct as exhibited in the common pigeon. Observe a male pigeon while cooing to his mate or his neighbors. Notice that he inflates his throat and crop, and that this feature is an invariable feature in the act, often continued for some moments after the cooing ceases. Compare the pouter and notice how he increases the inflation whenever he begins cooing. The pouter's behavior is nothing but the universal instinct enormously exaggerated, as any attentive observer may readily see under favorable circumstances.

THE INSTINCT OF TUMBLING.

The origin of the tumbling instinct can not be fixed by the same direct mode of identification; but I believe that here also it is possible to point to a more general action, instinctively performed by the dove-cote pigeons as the probable source of origin. I have noticed a great many times that common pigeons, when on the point of being overtaken and seized by a hawk, suddenly flit themselves directly downward in a manner suggestive of tumbling, and thus elude the hawk's swoop. The hawk is carried on by its momentum, and often gives up the chase on the first failure. In one case I saw the chase renewed three times and eluded with success each time. The pigeon was a white dove-cote pigeon with a trace of fantail blood. I saw this same pigeon repeatedly pursued by a swift hawk during one winter and invariably escaping in the same way. I have seen the same performance in other dove-cote pigeons under similar circumstances.

But this is not all. It is well known that dove-cote pigeons delight in quite extended flights, circling about their home. I once raised two pairs of these birds by hand in a place several miles from any other pigeons. Soon after they were able to fly about they began these flights, usually in the morning. I frequently saw one or more of the flock while in the middle of a high flight, and, sweeping along swiftly, suddenly plunge downwards, often zigzagging with a quick, helter-skelter flitting of the wings. The behavior often looked like play, and probably it was that in most cases. I incline to think, however, that it was sometimes prompted by some degree of alarm. In such flights the birds would frequently get separated, and one thus falling behind would hasten its flight to the utmost speed in order to overtake its companions. Under such circumstances the stray bird coming from the rear might be mistaken for the moment for a hawk in pursuit, and one or more of the birds about to be overtaken would be thus induced to resort to this method of throwing themselves out of reach of danger.

The same act is often performed at the very start, as the pigeon leaves its stand. The movement is so quick and crazy in its aimlessness that the bird often seems to be in danger of dashing against the ground, but it always clears every object.

As this act is performed by young and old alike, and by young that have never learned it by example, it must be regarded as instinctive, and I venture to suggest that it probably represents the foundation of the more highly developed tumbling instinct.

The behavior of the Abyssinian pigeon, which, when "fired at, plunges downwards so as to almost touch the sportsman, and then mounts to an immoderate height," may well be due to the same instinct. The noise of the gun, even if the birds were not hit, would surprise and alarm it, and the impulse to save itself from danger would naturally take the form determined by the instinct, if the instinct existed. This seems to me more probable than Darwin's suggestion of a mere trick or play.

Bearing on the above discussion of the instinct of tumbling, the editor finds a quotation from an article in *Nature*¹ to the effect that "pigeons have all three semicircular canals well developed." Concerning this statement the author remarked that "possibly the center of balance is so placed in these pigeons as to facilitate the tumbling."

Three letters from correspondents relate to the tumbling phenomenon, and were evidently intended for publication as illustrative of some of the points treated in the quotation that has just been given.

"What you have to say about the 'habit of tumbling' in pigeons prompts me to ask if you have ever heard that scoters, when flying in flocks at a great elevation, will almost invariably descend nearly vertically almost to the ground or water if a gun be fired beneath them. I have often seen them do it. I remember even firing at a flock which was approaching at a height of more than 1,000 feet and then with the second barrel, killing one of them as the flock dashed past me low over the water after their descent. Most of our sea-fowl hunters know this trick and practice it more or less often and successfully. It is the *report* of the gun, not the charge which it contains, which brings the birds down." (William Brewster, of Cambridge, Massachusetts, Nov. 23, 1899.)

"Last summer I observed a common mourning-dove in flight which—twice within a distance of an eighth of a mile—went through the process of tumbling like a common tumbler pigeon. I do not know if this is a common habit of the mourning-dove or whether it is of any interest. If you are interested I would be glad to tell you anything further you may ask so far as I observed. I have not known that wild birds had this habit." (Professor M. M. Metcalf, of Baltimore, Maryland, Jan. 4, 1900.)

In response to a request for further details of this instance of tumbling in the mourning-dove, Dr. Metcalf wrote as follows:

"Mrs. Metcalf and I were driving one evening last July in the Fox River Valley, north of Elgin, Illinois, when we saw the tumbler mourning-dove. It was about sun-down. I remember thinking the birds were probably bound for their roost, which I thought might be near the river some 2 miles east of us. There were three birds about 800 feet apart, flying fast in a direction almost due east. The middle one showed the peculiarity in flight. I have seen tumbler pigeons but few times, and could never tell what were the exact evolutions of the birds. The impression from this mourning-dove was the same as from tumbler pigeons I have seen—a sudden cessation of onward flight, a peculiar fluttering, the bird dropping backwards, then recovering its balance, and going on as swiftly as before. The drop was, I should say, about 12 feet, Mrs. Metcalf thinks more. The bird tumbled (?) twice in about an eighth of a mile. I watched them about as far beyond the point of second tumbling and saw nothing of the sort again.

"It was wholly different from a stopping in flight such as one often sees. The bird evidently lost its balance and recovered again. The three were flying swiftly, one behind the other, over prairie pastures. They flew low, within easy gunshot from the ground. When the first tumbling occurred the bird was about 400 feet from me. It did not pass quite over the carriage. No other birds were seen by me at the time, nor did I observe anything of interest in this connection. The first tumbling occurred in the middle of a pasture west of the road. The bird tumbled a second time after flying over a fence one field west of the road. There was a single tree about 150 feet from the bird toward myself which the bird had just passed when it tumbled a second time. The appearance of the evolution seemed to me to correspond to that of tumbling. There was the same startling fluttering effect.

¹ The Origin of Tumbling of Pigeons, *Nature*, 1901, p. 395.

The observation, however, to be of real value should have been made by one more familiar with tumblers than I am. Mrs. Metcalf confirms these estimates of distances." (Professor M. M. Metcalf, Baltimore, Maryland, Jan. 12, 1900.)

SOCIABILITY.

Two pairs of crested pigeons, when resting during the day, are often seen sitting "in close order" on the perch. When "roosting" at night they get as close as possible to one another, and the two pairs brought up in separate pens until Oct. 1st have never shown hostility to one another. The two older ones, as soon as they were attacked by the male of a pair of ring-doves, began to retaliate and soon made themselves masters of the pen. Their swiftness of motion and skill in striking terrific blows generally caused the male ring-dove to retreat. But the ring first claimed the nest-boxes and yielded his position there only occasionally, and then only for the moment. He too is no unskillful fighter. Although inferior in striking, he is quick to take advantage by flying upon the back of his antagonist, where he can scratch, peck, and strike with impunity. In this way he drives the much larger and stronger *Ectopistes*, and often puts to rout even the crested pigeons. The crested pigeons, while perfectly friendly to one another, regard the young *Ectopistes* as enemies on the perch at night (not while eating). This is due to the fact that the latter insist on free roosting-space and peck at intruders that come within reach. The crested pigeons therefore take care on their part not to let the passengers or the ring-doves come too near their section of the perch. If these do not keep at a safe distance, at least 6 to 12 inches away, one of the crested pigeons will attack furiously and return to his place only after having put the enemy at a longer distance than he would have claimed unmolested. The point seems to be to make it understood that there can be no trespassing on roosting quarters.

Two young *Ectopistes* never sleep side by side. They always claim free space on both sides—6 or more inches. The mourning-doves do the same. This is interesting in relation to the fact that the passenger pigeons are well known to prefer company in nesting and in feeding, keeping together in large flocks. Mourning-doves, on the other hand, seek a place apart for a nest, and only later in feeding or migrating are found in flocks.

The zebra-doves (certain *geopelias*) as well as the ground-doves of Florida (*Chamaepelia*) sit in close order at night, often struggling to get the inside place as the warmest. The same is true of *Geopelia humeralis*.

I have seen for a week or two that the second of a young pair, of crested pigeons, 74 days old, insists on roosting with its foster parents (ring-doves). This pair of ring-doves and two young passengers are all in the same pen in my library. The ring-doves are hostile to the older crested pigeons and often so to the younger, mistaking them for enemies. But these submit to being pecked rather roughly and snuggle down beside their foster-parents. The first of the pair has now finally deserted its foster-parents and prefers to roost with the older pair of its kind. The second young still insists on sitting beside its ring-dove parents.

A male crested pigeon mated with a ring-dove (*GF 1*) roosts on the nest-box close beside his mate. For the first two nights he sat on one side of the box and she on one end. To-night he took his place beside her, and so close that she several times withdrew to another side. He followed her each time and insisted on sitting as close as possible. At last she submitted and went to sleep beside him. Here we see the female cross her own instincts—of roosting apart. In the case of another pair, common-pigeon male and ring-dove female, the female learned to follow the male into the cot every night, while other ring-doves steadily preferred to sit outside.

It is possible that the "home instinct" might be developed in ring-doves mated with domestic doves and then allowed to go free. The male domestic would follow his mate and lead her back to the cot. A female ring-dove mated with an archangel follows him

into the cot and nests there. The same is true for female ring-doves mated with white fantails and black tumblers. In the reversed cross—i.e., where the male is a ring-dove and the female a homer—the pair nest in the cot, but the male sits out at night and she sits with him if she has no young or eggs to care for.

In a cross between a satinette male and a crested-pigeon female, both sit out of doors rather than in the cot. The male prefers to roost inside, but she persists in staying outside, and he finally, after several nights, concluded to stay out with her.

The young of *G. humeralis* are not weaned—or rather are not driven off by the parents—as early as in other species. A 7-weeks-old young has been treated kindly, and when I took him away the old male seemed to be quite disturbed; when night came the young called and the male answered and was long uneasy. Even the next day the young kept up its call and the male parent responded. The sociability of this species is evinced from the start by the young. They are extremely attractive in their fondness for their parents, in their sweet, almost musical notes, in their loving head-movements, in their roosting between the old birds, etc.

A young speckled-neck (*Sp. suratensis*) about 6 weeks old likes the company of his foster-father (a ring-dove), and seeks to sit close beside him at night. It is very interesting to notice its behavior as it approaches the old bird. It comes up in a very inoffensive, affectionate way, and before snuggling down beside the old bird puts up its beak and fondly caresses the head and beak of the old bird, as if to make sure of his good will and to win favor. It reminds one of the dog that crouches and wags its tail as it approaches its master in some doubt of a friendly reception. The same kind of behavior is very common with young pigeons of all kinds, and even with mates. The young of crested pigeons and of *G. humeralis* are peculiarly demonstrative in their social manners.

A 6-months-old crested pigeon was placed in a cage with an 8-weeks-old hybrid between a black tumbler and a ring-dove. The hybrid showed some affection for his companion, although he had been brought up with his parents and never before had seen a crested pigeon. This crested pigeon is very gentle and inoffensive, never attacking or showing the slightest disposition to quarrel. The hybrid soon learned that the crested was harmless and trustworthy, and “confidence” is a condition of friendly relations. Let a dove strike or peck and it may expect the same in return or to be feared and shunned. (B 2C, R 7.)

FIGHTING.

The young of the ring-dove show the instinct to fight at the sight of individuals of their own species and of other birds which are more or less strangers to them. The instinct is first shown in the nest at the approach of any strange object, such as the hand. The mode of fight is to swell up the breast and raise the feathers, or pin-feathers, so as to look “large.” The eye looks fierce and the mandibles are snapped, and with each snap a puff of air is expelled, much as a kitten “spits” in the face of an antagonist—a dog. If the hand is moved rather quickly, the young may strike with the beak and with the wing. All these movements are purely instinctive, or, shall we say, reflex acts?

After the young get out of the nest they are generally very inoffensive and seldom attack a companion. But when night comes and the roost is taken they become tenacious of their place and are quick to warn intruders not to come near. This is true especially of the domestic dove and of passengers, which do not sit in close order at night, as do the crested pigeons.

At first the instinct to fight may not appear at all during eating, although it is called out from the start on the roost. In the course of time they begin to claim food and to drive away those coming second. *Ectopistes* begins this quite early. The disposition to fight and drive other doves away from the neighborhood of the nest becomes strong as soon as nest-building begins, and is still stronger when the eggs are laid and after hatching. A

young passenger bristled up, raised his wings, and scolded fiercely at the crested pigeons in an adjoining pen as soon as the first egg was laid.

The disposition to fight is periodic and comes on in all pigeons at the time of mating and choosing a nesting-place. In a pair of homers, while fixing on a nesting-place, the male was pugnacious, fighting off other males whenever they came near. Just as soon, however, as the nest-place was settled and the two birds began to spend some time on the nest every day and copulations became frequent—about a week before laying—the male began to follow his mate jealously and closely, if other males were about. This male is now so anxious to guard his mate that he will not in many cases stop to fight off a strange male even from his own stand, but will keep his eye constantly on her, paying no heed to another male, except to drive his mate out of reach of the latter.

When a strange pigeon, *e.g.*, a homer, approaches on the floor of the pen, the Nicobar pigeon (*Cal. nicobarica*) raises its neck and back feathers, reaches forward with its head with beak open, threatening to bite (not to peck). It opens the beak and “grunts” as it “throws” its head towards the intruder with beak open. The head keeps moving as if the bird was trying to reach the opponent, but the purpose served is to frighten off the other bird. If the intruder comes quite near there will probably be no actual biting, but there may be a retreat or a defense by striking with the wing. The grunt sounds much like that of a pig that comes up to be fed or scratched.

I saw two bleeding-heart pigeons (*Phlogœnas luzonica*) threatening each other while taking their breakfast. The method was peculiar. The birds walked around each other at a distance of about $1\frac{1}{2}$ feet, each watching his opponent for an opportunity to get in a blow. One would dart on top of the other and give a blow with the wing and a peck, and then off, again walking around for another chance.

My Florida ground-doves (*Chamæpelis*), which are very timid and frightened at the least motion, have learned to trust me far enough to fly often upon my hand to get seed. But in doing so they usually raise one or both wings almost vertically, evidently with the design of protecting themselves from attacks or approach while eating. This practice of raising the wings in a fight, or in the presence of an antagonist, is widespread among pigeons, as is attested by the several instances next to be described.

The ring-doves, and pigeons generally, involuntarily raise the wings when suddenly surprised by a strange animal or a bird brought into their presence. They not only raise both wings, but nearly all the feathers of the body—especially those of the back—and spread the tail, ready to defend themselves or to escape by flight. Common pigeons in fighting often raise the wings to guard against the blows of their opponents. A ring-dove learned to raise his wings and lower his head when a crested pigeon approached to strike him. He finally learned that he could drive the crested pigeon by flying upon his back. In this way the ring-dove claimed and held his nest-box, although at first he had to surrender it.

My bronze doves or green-wings (*Chalcophaps*) and my *Geopelia humeralis* both raise the wings high when threatened by another dove. The bronze doves always raise both wings as high as they can reach when attacked and during a fight. I have noticed too that these birds, on getting a hold on the feathers of an antagonist, jump, helping themselves with their wings and legs much as common fowls do. *G. humeralis* raises the wings in precisely the same way. This bird is decidedly courageous, a fact made evident by the following paragraphs:

My small *G. humeralis* do not hesitate to attack the large white-wing pigeon (*Leucosarcia picata*), and the latter allows itself to be driven about. It is like a pigmy driving a giant. The white-faced pigeon appears to have no spirit for fighting and not wit enough to defend itself against *G. humeralis*. Most doves are quick to understand that they can whip doves of smaller size. But the *G. humeralis* continually lords it over the *Leucosarcia*. One little fellow drove both of the large birds into a corner, where they tried to hide their

heads from him. There they stood in abject submission to the little bully. Twice I saw a *G. humeralis*, after driving them to the corner, coo before them with a bowing and raising of the wings and tail, in the manner so characteristic of the crested pigeon. In this case it was a crow of superiority.

I received by express in the same shipment, 4 specimens of *G. humeralis* and 2 of *L. picata*. I was astonished to see that at the outset one of the little geopelia was actually driving the large leucosarcia and catching hold of the neck-feathers and twitching them with all its power. The white-faced pigeon stood and took it all without returning a blow, merely raising one wing to shield itself. The geopelia quickly discovered that they could bulldoze their larger cousins, and they had sense enough to take advantage of the stupid impotence of their big companions. It is hard to define, but it is evident that *Geopelia* has a higher *grade of intelligence* than the white-faced pigeon. It was ludicrous to see so large a bird imposed upon by a mere pigmy. Courage in birds often means intelligence.

In the struggle of two common-dove cocks for mastery of a roost or nesting-place we see strong determination and an appreciation of any "advantage of position," such as the inside position on a shelf. Any advantage of "hold" is maintained as long as possible and made the most of, as when one gets the other by the feathers on the side of head and holds him so that he can not return any blows. Once I saw a fantail take a homer by one of his primaries and run him around a yard without once giving up the hold.

I placed a young domestic, full-fledged, in a cage with a passenger. This fellow would eat from my hand and would peck at the wild passenger when it came to eat with it. If the wild pigeon went off his courage was of course good; but if the wild pigeon retaliated he at once lost all courage to fight and would try to hold his place by lovingly fondling the feathers of the head of the former. I saw this done several times, and I take it to indicate almost human intelligence in dealing with opponents.

A male domestic dove, which is mated to a female ring-dove, is wild and afraid to eat from my hand. I pretend to be afraid of him, putting my hand slowly towards him, and then withdrawing it as if in fear of him. He at once took courage and came to attack me. As long as I kept up the play he was brave and seemed to think he had mastered. In the course of a few days he became bold enough to fight vigorously. The dove is thus quick to take advantage of fear in its antagonist, as is the case in so many of the higher animals. I have a male blond ring-dove that is fearless and easily induced to fight, although ordinarily he treats me as a friend and never thinks of pecking at me even when I lift him from his nest.

Doves frequently make a show of courage just to intimidate. If they succeed in this way they follow it up and practice it on every occasion. They remember that it works well. This was well illustrated in my mourning-doves. The smallest of the flock of 10 found that a sudden jump was enough usually to frighten off his large companions, and in this way he drove every bird in the pen. I have known a mourning-dove to frighten the much larger ring-dove in this way, and so drive it about. Sometimes the wings are thrown outward with a quick jerk, as if threatening to strike. *Ectopistes* does this when it scolds.

If pecked at by old birds, the young squeal and beg with their wings. If abused they hang their heads low and submit without an effort to defend. Often they will endure very rough treatment without moving; often they will turn and run in search of a place of safety, generally to the nest. If pursued and there is no escape, they will stand and be scalped—let the feathers be stripped from the head and back, flayed alive, but bearing it with the heroism of religious martyrs. This endurance of severe pain without resistance or attempt to flee is sometimes exhibited by adult pigeons; *e.g.*, an adult geopelia, attacked by a fellow, hung its head and stood motionless until the other tired of the attack. In a case where the old birds wanted the nest for a new set of eggs they began to drive their young of 3½ weeks. These, wonderful to say, bore it for a while, and then began to resist and fought with such desperation that the old ones left them. I saw this repeated several times. (R 7, R 17.)

FEAR.

If one or more doves become frightened *at night* and flutter in the attempt to go through the window or wire netting of the pen, the fright is thereby communicated to other doves in the same room or within hearing. One night, at 1 or 2 o'clock, a young mourning-dove, about 4 weeks old, got startled and flew against the window, fluttering vigorously. The fright became general, and two quite tame mourning-doves at the opposite side of the room were so alarmed that both dashed violently against the wire, the female leaving her eggs. A pair of tiger turtles were sitting at the same time; the male left his perch and was found on the floor; the female of this pair was badly frightened, but did not leave her eggs. I have several times seen a whole room full of ring-doves fearfully frightened by the fluttering of a wild passenger-pigeon, though the ring-doves were perfectly tame. Fright by night, when the bird can not see the cause of the disturbance, is often extreme and easily communicated. *Wildness* also is often communicated by example. A single wild dove among a dozen tame ones will often turn them all wild, just as a tame dove will often help in taming wild ones.

Four of my passenger pigeons have never had their freedom, having been raised by Mr. Whittaker, and although only 3 or 4 years old, they have behaved as if terror-stricken, and their fear has disappeared only very gradually and so slowly that I can but wonder at it. A mourning-dove which I obtained from Florida was far less timid and learned to eat from my hand with confidence in a few days. But the passenger-pigeons, although I have compelled them to accept all their food from the hand, were very difficult to manage at first, and to this day they have not lost their fear of me. They were taught to eat quite readily from the hand, but they watched every movement of my person and often tried to get through the wire screen of the coop. At first, in order to break them in, I kept them in a large cage near my writing desk and spent much time in trying to get them accustomed to me. For weeks I could not go to the cage without alarming them; they would dash against the wire so recklessly in trying to get away that they broke off the ends of their wing-quills and tail-feathers, and made their wings bleed from the wounds caused by flapping against the wire. I have lately allowed them to eat from the shelf and they have grown wilder, so that they now refuse to eat from my hand.

A young *G. humeralis* (7 weeks old) had been separated from its nest-mate soon after hatching and placed under the care of ring-doves. To-day I brought the two together. The one that had been under the care of the ring-doves was terrified at the sight of its own mate and raised its wings and bristled up for defense. This occurred toward night. I left the two together in a pen by themselves. The two still kept apart the next morning, or rather the one brought up under its own parents seemed not to fear the other much, but the other continued to manifest great fear. This fact shows two things: The one brought up under its parents, and familiar with its own species, saw no cause for alarm in its mate; but the latter, brought up with ring-doves, recognized its mate of its own species as a *stranger* and an *enemy*. These two birds were kept by themselves in a cage and after 4 days they finally got acquainted and roosted together side by side.¹ (R 23, SS 4, R 7.)

FOOD.

I have noticed that the *Ectopistes* parents, especially the female, searches the ground over and over, looking under the plants and along the edge of the boards. Is she hunting for worms or insects? Whatever the object may be, I have seen both male and female on the ground searching and working in the grass with the beak, as if to find worms. On a later occasion I placed a handful of earthworms in the food-dish of a cage containing an

¹That the alarmed white-faced pigeon (*Leucosarcia*) attempts to "hide" by lowering the breast and head to the ground—standing still, with tail raised toward the source of danger—has already been mentioned (Chapter V, topic, Hiding on Nest). In the case there cited a young bird of only 18 days displayed this behavior.—EDITOR.

Ectopistes young only 32 days old. This bird was hatched under ring-doves, had been reared under them, and had never before seen a worm. After a glance or two the young passenger descended from his perch, took up a worm, tried it at the end of his beak, and then dropped it. After repeating the act three times he at length swallowed the worm and then ate several others, generally testing them a little first.¹ I have noticed that the green-winged pigeons (*Chalcophaps*) eat earthworms, and occasionally the ring-dove will do so. The large white-faced doves of Australia were seen to eat several earthworms which were thrown to them.

I find further that stock doves (*C. ænas*), the guinea-pigeon (*C. guinea*), and its hybrids (by homer), Japanese turtle-doves (*T. orientalis*), ring-doves, and hybrids between Japanese turtles and ring, all eat earthworms when they have young to feed. I am inclined to think that pigeons very generally eat earthworms.

Grass is much liked by wood-pigeons (*C. palumbus*) as well as by other pigeons. They also like the plantain leaves growing in the yard. Lettuce is eaten quite freely by pigeons generally. Salt (rock) is very necessary, as is cuttlefish-bone² and ground oyster-shell. (SS 4, B 2a.)

BATHING.

I watched a young *ectopistes*, a little more than 2 months old, take its bath in a shallow glass basin. After trying the water by immersing its beak and shaking it, it plunged in and gave itself a vigorous shaking several times. After each shaking it would lie over on one side and lift up the wing of the other side, stretching it vertically or a little inclined and as far as it could reach. I have often noticed this habit of lifting the wing during a bath in other pigeons. They frequently perform these same motions when it rains, especially if they are disposed to a bath. The wing is raised so as to expose its under surface to the falling rain. The same movements are also often employed in "sunning" themselves.

A 3-weeks-old hybrid between a white fantail and a ring-dove, which was just about ready to fly a little, discovered the water that was kept in a basin about 3 inches deep. The bird felt the desire to bathe, but, not knowing how to get into the water, simply ducked its head and squatted outside the dish and shook its feathers as if in the water. Soon afterward it found its way to the edge of the dish and then jumped in and took a good bath in the approved style. This was certainly the first bath. (R17, R7.)

INSTINCTIVE PREFERENCES.³

Ring-doves do not seek the coop to escape the rain, but sit out in the heaviest showers, even when a coop is near at hand. The young and old behave alike, even when accustomed to spending the night inside. The domestic dove usually goes in out of the rain. Domestic pigeons prefer the coop to the open at night. Ring-doves have to be forced to go in. In time they learn to roost inside, but only after being repeatedly driven in. A particular ring-dove female which I have mated with a common pigeon follows her mate into the coop without any assistance.

A male common pigeon and a Japanese turtle had a nest and eggs in a pen on the east side of the house. The nest was on a shelf and was covered by a box about 2 feet long. One-half of one side of this box was open. The female laid her first egg in that end of the box having the aperture. When the male took the nest the next day he moved the nest and the egg along to the other end of the box, away from the aperture. The female in

¹ See Chapter X.

² I do not quite know why the birds eat so much cuttlefish-bone. It seems in some way to promote their digestion and general health. It probably contains a good deal of salts, which may have a beneficial effect. Some of them do not eat it; some have never learned to do so. Those which do eat it usually grow passionately fond of it. When they see me bring some in and break it up for them, they understand and make a great commotion. (Conv. 7/2, 10, W. C.)

³ Other illustrations are given in Chapter X.

turn moved them back before the opening, when she took her turn at incubation. This behavior was repeated by each on the two following days. The male thus preferred to nest under cover, under that part of the box which was entirely covered, while the female preferred an open space for the nest, *i.e.*, she preferred that part of the box having one open side. (R 17.)

APPRECIATION OF HEIGHT.

A young white ring-dove, which had been kept on the floor of the cage in a box 3 inches high, jumped out of the box for the first time. This bird was unable to fly and yet ventured out of the nest, which it would not have done if the nest had been placed at a greater height from the floor. This shows an instinctive (?) appreciation of distance and safety. Similarly a young hybrid between a white fantail and a ring-dove, when just 2 weeks old—a full week before it would venture to fly from its nest—stepped out of the nest-box, which was kept on the floor of the pen, to the floor and walked around with the foster-parents, which were eating their breakfast. The young bird then, without experience, appreciates the conditions which make it safe or unsafe to leave the nest. If this nest had been several feet above the floor the young bird would not have ventured out for at least a week. (R 7, R 6.)

SLEEP.

I notice that pigeons fall asleep very quickly after getting to their accustomed place on the perch at nightfall. But they are easily aroused. Every time I come into my room, and every time I move with some noise after a period of quiet, they are awakened, and they habitually shake their feathers quite vigorously all over when thus aroused from sleep. It is interesting to hear this shaking run through a dozen or more doves all at once. The eyes are closed in sleep and the head and tail are held in nearly the same horizontal plane, so that the dove, especially when roosting in the open air, looks as if it were on the watch for enemies from below. That is the attitude only when they hear something. In the cages the head is held a little higher, but the body is nearly horizontal. The bird supports itself by resting the body on the perch, as they sometimes do in the daytime when they drop the wings beneath as supports and as an aid to balance.

Crested pigeons sit on the perch with the head, body, and tail in a nearly horizontal line, the tail falling but a little beneath this line. The head is so held that the crest is vertical and in line with the beak, which is drawn so close to the breast that it is almost covered with feathers. The eyes are closed, and the appearance is that of sound, restful sleep. Slight noises arouse them to open an eye, but it soon closes. They sit as close together as possible, not for warmth, for they do so in warm weather, but because they are fond of company and feel a satisfaction in close contact. The young crested which were reared by a pair of blond rings were accustomed to crowd so close as to push the old birds off the perch; and they would not rest until they succeeded in nestling close to one another.

The passenger-pigeon holds its head in sleep somewhat higher, but drawn back upon the breast, so that the beak is pretty well covered with feathers. The tail droops to an angle of about 45°. In both passengers and crested the beak is held straight in the middle line of the breast. (R 17.)

MODIFICATION OF INSTINCT.

I notice that a pair of young mourning-doves, only 1 and 2 days old, are sleeping quite uncovered in front of their parent. The young birds are in the nest and the parent bird seems to have drawn back a little to one side of the nest, so that the young can sit uncovered. The heat is oppressive (June) for the first time this season, and the birds are left uncovered because more comfortable so. In cold weather this would not happen.

Wildness is often communicated by example. A single wild dove among a dozen tame ones will often turn them all wild, just as a tame dove will often help in taming wild ones.

At Woods Hole I have mated blond rings with dove-cote pigeons, have allowed them to go entirely free, and have not lost one of them. The only difference between them and the common pigeon is that they delight to go into trees, and if they get frightened they go to some tree; the common pigeon avoids trees and alights on the roof of some building. It is extremely interesting to note the behavior of the male domestic pigeons which I had mated with these birds. The male takes a very jealous interest in his mate and follows her wherever she goes. The moment she flies from the perch he is after her. But the ring-dove is swift of wing and sometimes gets out of sight. On such occasions the male is very anxious and flies about in search—calls, and flies and looks. Usually, if the ring flies away some distance, she comes back to the place she has left, and then the mate is ready to meet her. From her mate she “learns” to take up her quarters inside in the dove-cote. If both of the pair are blond rings and they are set free, they prefer to roost outside. It is only when mated with the dove-cote pigeon that they will roost inside. Sometimes they will then go outside; as a rule they will follow their mates. Sometimes I have observed that the dove-cote pigeon has “learned” to fly into trees.

ILLUSTRATIONS OF VARIATION OF HABITS AND INSTINCTS—INDUCED AND SPONTANEOUS.

A female ring-dove learns from a male crested pigeon to sit in close contact on the roost at night. A female ring-dove learns from a male common dove to roost inside the dove-house rather than outside, and to go in for shelter from the rain. A *male* fantail broods the young at night. A *male* white ring-dove sat on the egg the first night after it was laid. A young hybrid fed a companion of the same age. A male passenger-pigeon sat regularly of *nights* on the eggs, while the female sat on the edge of the box. A pair of crested repeatedly laid sets of eggs before the previous set hatched, so that they had 4 eggs to sit upon. A female *G. humeralis* mated with a ring-dove does not flee from him after a union, as she does from a mate of her own species. Her difference of action is due to the different behavior on the part of the male. The male ring-dove allows himself at this time to be fondled by the female and she expresses her joy by so doing. The male *Geopelia*, on the contrary, bristles up in a most savage manner, repels her love, and drives her off, acting as if his pleasure had turned to displeasure and nausea.

DOMESTICATION OF AFRICAN GUINEA-PIGEON.

A young guinea-pigeon (*C. guinea*) was hatched under a pair of pouters in April, 1909. It was transferred when 5 days old to a pair of owl pigeons. It came out of its cot when 29 days old, and flew to the ground into the back yard with one of the owls. I allowed him to go free and he continued to return to his cot and to go inside at night. I removed one of the owls on the same day the young guinea came out, in order that the other owl might give full attention to the young guinea; this he did, and all went well. 13 days later the young guinea went into his cot as usual, but he was alone, as I found next morning, the owl having been accidentally shut into the barn and thus prevented from returning to the cot. At 6 o'clock, the next morning I was unable to find the young guinea anywhere. He had probably left his cot early that day in search of the owl, which had continued to feed the young bird in part. Not finding his foster-father, he probably flew off in company with some passing stranger, mistaken for the owl. At any rate, the guinea-pigeon was not to be found, and as he did not return at night I concluded that I should probably never see him again.

All of the following day I kept on watch, but the lost bird did not appear until between 5 and 6 p. m. When I came home at about 6 p. m., however, the young guinea was sit-

ting quite composedly on the cot-stand. He soon went inside and I closed the door, inclosing both the owl and the guinea. Three days later, at the age of 9 weeks and 4 days, this bird died, probably of indigestion, after a short illness. Up to the last it continued to remain at home, and to share the cot with the male owl.¹

Although this bird lived a little less than 10 weeks, I feel sure that it demonstrates the possibility of successful domestication in this species. My experience with other species leads me to think that any of them, of similar nesting and food habits, could be easily domesticated; and still more easily, if one lived fairly isolated in the country, where the birds would have but one home, shelter, and supply of food. (R6, R23, A1/1, R17, X S3.)

SUMMARY.

The naturalistic account of various bits of behavior hardly permits of an adequate summary. Marked specific differences are noted, but no generalizations of species relationship are possible. The phylogenetic conception of the evolution of instinct previously developed for incubation and homing is again asserted of tumbling and pouting. The traits of these two breeds of pigeons are but unusual developments of powers and tendencies common to all pigeons. In addition to those cases noted in connection with the reproductive cycle, several interesting examples of modification of instinct are described. When two birds possessing different tendencies are mated, one bird will modify certain instincts so as to adapt itself to the unusual social situation. A female will roost close to her mate, although her natural inclination prompts her to roost with some degree of isolation. Some species naturally roost in a cot, while others prefer to roost outside. In a mating of two birds with such opposed tendencies, some pairs will roost inside, while other pairs will stay outside for the night. In such circumstances a free bird may nest inside a cot when its natural tendency is otherwise.

By social pressure, dove-cote pigeons may be induced to fly into trees. In the cases cited it was the female bird that adapted herself to the male in the majority of cases, but the rule is not universal. The modification of instinct in the above cases may be considered as due to a conflict with other tendencies, *e.g.*, the instinctive and acquired preference for the mate. The social influence is again evident in such traits as wildness and fear. The capacity to learn is also mentioned. Attitudes of fear or trust toward other birds or man are modified by experience. Courage in fighting is strengthened by success. New modes of attack, occurring accidentally at first, are retained when successful, and ring-doves will acquire the habit of roosting inside after being driven in repeatedly.

¹ I had removed the owl mate at the time when she began to lose interest in the care of the young guinea. I did this so that the old owl should not turn against the guinea and drive it out of the cot, as it would do if the female owl had been allowed to remain and renew her nest. In fact, she had already become a little hostile to the young. After I removed her the male owl took more interest in the young guinea and seemed to regard it as a mate. The guinea was a splendid bird, and it is a surprise that it should die. I think, however, that coarse seed may have been responsible.

CHAPTER XIII.

HABIT, INSTINCT, AND INTELLIGENCE.

In this chapter the editor has grouped under appropriate topics all those observations of activities in which the effect of previous experience is evident. The material is thus significant from the standpoint of learning, habit formation, and intelligence. For the final topic we have added a selection from a lecture which states in a very succinct form the author's view of the relation of intelligence to instinct. Intelligence, according to Whitman, is not a power, force, or faculty; it is the capacity to learn, to form habits, to profit from previous experience. Instincts are not always perfect; they have faults or deficiencies, they may conflict or interfere with each other. They are not absolutely stereotyped or invariable in their expression, but are plastic or variable to some degree. Intelligence is the capacity to learn, to adjust to novel or variable conditions, and hence is a result of this plastic and variable aspect of instinctive organization. As to the meaning of "memory," the author follows rather consistently the biological usage of the term. To the biologist, memory is the capacity to form habits, and any act exhibits "memory" in so far as it is the resultant of previous experience. Memory is thus equivalent to intelligence. Some readers may prefer a more restricted usage of the term, but questions of terminology are relatively unimportant in comparison with questions of fact and interpretation.

Pigeons are generally regarded as rather stupid creatures, but every organism is relatively stupid along certain lines and relatively intelligent in other respects. As the author states in a footnote in this chapter, an animal may exhibit a good memory for certain activities and a poor memory for others. Pigeons are unutterably stupid from some standpoints. They may injure their young in feeding them, cast the young bird from the nest along with the shells, and incubate, day after day, an empty nest. Yet pigeons do learn quite a variety of things, and some acts are mastered with a surprising degree of readiness. Besides the material given in this chapter, other illustrations of learning capacity have been noted in the summaries of Chapters IX, XI, and XII. A perusal of this material should convince the reader that the pigeon is not altogether stupid, that intelligent capacity does exist, that certain acts are learned very quickly, but that this intelligence is manifested only in certain situations and for certain types of activity. For convenience these powers may be roughly grouped in several classes:

(1) The capacity to acquire habits of reacting to the position aspect of objects is noteworthy. In this respect pigeons are not different from most other animals, for this power is deeply seated and widely distributed in animal life. For the prevalence and significance of this gift we may offer the following suggestions: Among active animals endowed with strong powers of locomotion their position in reference to the topography of the country is of necessity highly variable. Many animals are so organized that certain fixed positions are essential to many of their

activities. Feeding-grounds and breeding-grounds are illustrations. In the pigeon most of these needs center around the nesting-site and its immediate vicinity. Such animals must be able to react to topographical relations. An instinctive organization will hardly suffice for an animal whose relation to the environment is exceedingly complex and variable. Instincts are adaptations to the relatively fixed and constant aspects of environmental conditions. The ability to learn easily and quickly a complex system of topographical habits would thus be one of the fundamental needs of animal organization. Most animals have the degree and kind of intelligence which their life demands. Many illustrations of this capacity of pigeons are given. The preference for a roosting-site may be established in one night. In "pair *D*" the preference for a new nesting-site in a box filled with dry dung was fixed with one experience of an hour's duration. A male broke one nesting habit and developed a new one in 5 or 6 trials. The nest is not wholly an object, but partly a position in reference to other objects. Freed birds at first are lost, but they learn to locate the nest in a large yard in a couple of trials. The ability of homers is supposed to consist of this capacity to learn quickly and retain tenaciously a complex system of topographical habits. Viewed from this standpoint, one is almost tempted to assert that pigeons possess as much intelligent capacity as humans for these particular lines of activity.

(2) Pigeons are also able to acquire rather readily systems of differential reactions to the individuals of the group. Because a bird can acquire a habit of reacting to another bird as an individual, *e.g.*, a mate, it does not follow that as a matter of fact it does acquire a habit for each individual of the group. The differentiation may be between mate and not mate, species and foreigners, member of flock and stranger, etc., but individual reactions are possible. While certain distinctions such as species, sex, and enemy find a basis in instinct, yet instinct does not provide in advance for all possibilities of individual differentiation. While such species differentiation is partly innate, it is to a large extent acquired.

A novel species reaction was acquired by a young *geopelia* at the age of 7 weeks. Placed with its own kind, a new reaction was acquired in less than 4 days. The selection of a mate is at first a process of discovery; each bird reacts instinctively to a certain type of behavior. After the mating is established, however, the members of a pair react to each other on a different basis. They react to each other as individuals and recognize each other at a distance. This new mode of reaction is acquired and easily established. A pair of young brought up with each other will have learned at the age of 4 weeks to respond differently to each other than to others of like age and species. Inside of a large group smaller groups are formed and differential habits established. Attitudes of fear, distrust, and confidence toward individual birds are very easily modified with experience.

(3) Many acts are improved through *exercise*. The influence of experience is probably influential upon all of the fundamental activities. Illustrations noted in the manuscripts refer to such activities as egg-laying, flying, drinking and eating, and methods of fighting.

(4) The emotion of fear exercises a disturbing influence upon all instinctive and acquired activities and attitudes, and these disrupting effects are tenaciously *retained*. Acquired attitudes toward other birds, humans, and other animals can thus be inculcated. Roosting habits will be disrupted with one experience. The incubation activities are likewise permanently affected with a single experience. The ability to be easily affected and permanently *influenced* by fright is very essential for timid animals. Fear alone is hardly sufficient; a further value is contributed by the retention of these effects.

Pigeons thus have a facile intelligence for some things, but the capacity is extremely limited in scope. Intelligence, in the main, supplements instinct and ministers to the more fundamental needs in so far as these can not be completely provided for by an instinctive organization.

HABIT OF PLACE OR POSITION.¹

(1) On Apr. 25 I placed a nest-box containing a pair of newly-hatched young and the male parent on the floor of the coop. This male is perfectly tame, having not the least fear of being handled. He sat quietly on the nest-box while I placed it on the floor. After remaining on the floor a few minutes he walked off from the nest and flew up to the empty box which had previously contained the nest-box; he went into this box and sat down as if covering the young. I repeated the same experiment several times on this and the following day, and he behaved each time in the same way. The female on two occasions, seeing the young left uncovered, took her place on the nest, although the nest was on the floor and not in its usual place. In the case of the male it is evident that the *habit* of sitting in a box 3 feet above the floor of the coop, at a fixed elevation and position, had become so firmly established during the two preceding weeks of incubation that he felt that he was in the wrong place. He takes and feels contented in *the place to which he was accustomed*, notwithstanding that the nest and young have been removed. The nest-box and young do not satisfy him, except in their usual place.¹ He leaves them without any signs of hesitation, unless the few moments of delay be such. He is apparently *quite blind* to the purpose of his instinct of brooding. The *habit of place* is stronger than the stimuli supplied by nest and young. He would probably leave them to die of cold and hunger. The female in this case displays a higher power of adaptation—a better appreciation of the needs.

On Apr. 28, at 2^h 30^m p.m., I fed the female on the floor of the coop; the male, seeing this, left the young and came down to eat. While he was eating I again placed the nest-box on the floor. After a minute or two he turned around, looked at the box with young, and then flew up to the empty box; not finding his young, he turned right-about-face, as if to leave the box, but soon decided to remain, and went in and sat down as if all was right. Meanwhile the female went to the young on the floor and fed them both at once. She certainly understands her business better than the male. But it is also evident that *the male is conscious of not finding the young as he expected to do*, for his turning around as if to leave the box shows that.

On the following morning, at 9 o'clock, after the male had taken the nest, I again raised the nest-box out of the containing-box, holding it a minute or two at the level of the latter; then I lowered it half way to the floor, held it there for about 3 minutes, and then placed it on the floor. The male sat on as if he would remain, but after 5 minutes he got off to attack a male in the adjoining coop, ate a little and drank; he then went up to the

¹ Numerous other instances of memory for "position" are given in the chapter on the Homing Instinct.—EDITOR.

empty box and quietly sat down as if all was right. At 9^h 39^m I took him from the box and placed him on the nest-box. He felt the young and finally covered them, but not without looking up once, as if in doubt whether he should not return to the old place. He settled down, however, and remained. I left the nest-box on the floor overnight, the female remaining contentedly. The next morning, at his usual time to take the nest, the male went to the nest-box while it was still on the floor. He has now become *habituated* to finding his nest on the floor of the coop.

(2) The above experiment was partially repeated with a pair consisting of a white-ring male and a blond-ring female. I took the nest-box from the containing-box and placed it on the floor of the coop. The nest contained one young about 1½ days old. The female soon left the nest and flew back to the empty box, which, in this case, was about 2 feet above the floor. She saw that the young and nest were not there, and immediately returned to the floor and went on the nest. Although she was not satisfied with the nest on the floor, she recognized it and did not blindly desert it to sit in the habitual place. Here intelligence, instinct, and habit all come into play. There is *the instinct to sit on the nest and young, the habit of place, and the intelligence which is sufficient to correct habit.*

(3) I have a black tumbler (common pigeon), which I imported from Japan, mated with a blond ring-dove. These doves have eggs on which they have sat about a week. They are kept in a pen outside of the house. The nest-box is about 10 inches square and 2 inches deep. Wanting to bring the birds into the house to protect them from the cold, and knowing that the female would perhaps desert the nest, I took the precaution to change the egg to a smaller box (one about 8 by 5 inches) which would go into the door of a small wire cage. It was about 4 p.m. when I put the egg in the new box and the new box into the old one. Its surroundings were therefore the same as before, but the box was narrower and deeper (about 4 inches deep). The female, although she noticed the egg and got into the nest, refused to cover it and soon came out, apparently feeling non-plussed. I then returned the egg to the old nest-box, taking away the new one, and she at once went on the nest and covered the egg. After 10 minutes or so I again repeated the experiment with the new box and with like result. Again giving her the old nest-box and egg, she was contented and sat. After 15 minutes I again changed her to the new box. She did not like the new place, jumped several times to the edge of the box, but returned, and examined the nest as if strongly doubting that it was her own. After some time in sitting, turning around, and getting up, she at length decided to occupy the box. Had I brought it into the house or removed it from its place she would have deserted it. At 10 o'clock that night I brought her and her mate inside, keeping them in the dark all night.

The next morning the female came off the nest and remained off, and the male did not take his place. At 10 a.m. I placed the new nest out of doors in the old pen and she went on with hesitation and perplexity, after looking and examining to see if it was really her nest. There is evident, in this female, a mental activity of a very low order. She recognizes the *difference* between her nest and the one offered her, and, although she wants to sit, she declines to do so except on her own nest, and she is only brought to it by sitting overnight on the new nest when she has no sight to disturb her confidence. She *remembers* her old nest in the morning after it was removed, as she still behaves as if puzzled to know what to do, and as if wanting to find what she had known as her nest.

On the following night, after dark, the female was found off the nest and the male was on; I then returned the old nest-box again, and strange to say, the female felt it at once to be her nest and took her place over the egg! Several times I tried to get her to cover the egg in the new box, but she could not be induced to do so, and I therefore left her in the old box. As a result of my experiments and the cold weather the female finally deserted the nest.

(4) The female of "pair *D*" was true to the impulse to sit, but having sat for a short time in an empty box, she felt impelled to repeat the action in the *same place*. The presence of the eggs was of no account to her, and "seeing" them or "feeling" them did not call the bird to her proper business. Even the sight of her sister on the nest, and her departure, had no effect in preventing her from returning to the place she had adopted. She persisted during all of the second day (and the record¹ will show what followed later) in sitting in the empty box after having been driven away many times, and after the box had been covered.

(5) A male ring-dove mated with a common dove had been kept in a cage for 3 or 4 weeks. On opening the door to let them into a pen the female soon walked out; then the male, anxious to follow, started to go through the door, but in passing halted and held his head back with manifest fear of striking it against the wire, which was not there. The head was held back and turned at right angles to the body with just the motions the bird would make to avoid hitting the wire. The bird had become accustomed to avoiding hitting the wire, and acted, *not from a sense of sight nor from feeling*, or any other *external stimulus*, but from memory. It expected to meet the wire where it had always found it before. Such action does not imply that the sense of sight is not used, but that the bird did not act on a sight stimulus, since it has a contrary internal stimulus. When a door is opened the bird usually behaves, in the course of a longer or shorter time, as if it noticed it, but it only gradually comes to trying to pass.

(6) The return of the parents to the nest, to call the young back for feeding after they have wandered out, seems to be by *force of habit* rather than by instinct. From the outset the young have been fed in the nest and the parent comes to associate the nest with feeding, and hence keeps up the habit some time after the young have learned to walk about on the floor of the coop.

(7) Some pigeons show a peculiar tenacity to hold their first chosen spot for roosting. They insist on the identical spot, and sit in the same direction, often fighting for it as for life. It is remarkable how persistently a dove seeks to gain the place it has once roosted on, often taking precisely the same position with the head directed one way. If turned around they immediately resume the old position. If one of a pair has had the right end of the perch, and his mate happens to get this first, then both are *uneasy* and appear to feel that something is wrong. They often work some time to exchange places, and then they settle down contentedly. I have seen the birds of many caged pairs take up precisely the same position and direction night after night. If a position is changed one night, it is usually repeated the next.

(8) A young homer flew from the nest out into the yard and the male parent accompanied it. It was captured and returned. The father seemed to be anxiously looking for the young after I captured it and removed it from his sight. He flew back several times to where he *last* saw the young sitting, and then went to other windows, as if searching for it.

(9) The young of pigeons and doves usually turn so as to sit with the head pointing backward under the parent. This position is the one almost invariably taken by young passengers, ring-doves, crested pigeons, and domestic doves.

(10) A female ring-dove had a rather poor nest and one of her eggs got separated a little from the other; it was lying just outside the space covered by the bird, but quite near enough to be touched by the bird's feathers. She did not even try to cover it, and I found it still outside on the next day. It finally got several inches away, never receiving any attention. A second occurrence of the same kind was noted some time later. (R17, R7.)

¹ These experiments with pair *D* are described in detail in Chapter III, under the topic "Pairing of Two Females."—EDITOR.

RECOGNITION OF INDIVIDUALS.

Old birds distinguish their own young from other young and from adults in wild species, where marking, color, size, etc., are so nearly alike that we can not distinguish individuals. Birds are able to distinguish their own mates instantly. I think, too, that the parents remember and recognize their young, but not as offspring. They have no more interest in them than they have in any other bird. They seem to know them; they remember things of that sort. They remember individual birds. Every bird in a flock remembers every other bird, but I do not think they know any particular birds as their own offspring.

A young *Geopelia humeralis*, 7 weeks old, had been separated from its mate soon after hatching and placed under the care of ring-doves. Later I brought the two together. The one that had been under the care of ring-doves was terrified at the sight of his own mate, raised his wings, and bristled up for defense. This was toward night. I left the two together in a pen by themselves. The next morning, the two still kept apart, or rather the one brought up under its parents seemed not to have much fear of the other, but the latter continued to have equally great fear. This shows two things: the one brought up under its parents, familiar with its own species, saw no cause for alarm in its mate; but the latter, familiar with ring-doves, recognized its own mate—the same species—as a “stranger” and as an “enemy.” These two birds finally got acquainted, when kept by themselves in the same cage, and now after 4 days together they roost together, side by side.

Two pairs of young common pigeons, each pair about 4 weeks old, were reared in nest-boxes on the floor of two adjoining pens in my library; they were reared within 3 to 6 inches of each other, being separated only by a coarse wire netting. Here these two pairs could see each other plainly and were therefore not strangers by sight. To-day I put both pairs together, removing the old birds from the pen in which they were placed.

They did not at first appear quarrelsome at all, and I supposed they were to get on kindly together. But when night came one pair got into a nest-box about 8 feet above the floor and refused to allow the other pair to sit with them. The pair that were masters were very cordial to each other, fondling each others' head, etc., and never making the mistake of attacking each other while battling off the others—a mistake easy to make when four doves are contending for a place less than a foot square. One pair was driven out and, when I put them back, they were hustled out more quickly than before. I then gave them a perch below the box, and here they sat close beside each other, while the victors sat above them. The next night the victors took the place they had won and the conquered took the lower seat. The matter was settled; each knew its place. The mates of each pair were fond of each other, but the two pairs did not like each other.

Sitting side by side in the same box, the mates had evidently acquired a *filial affection for each other*, and they felt differently towards the other pair and always kept up the distinction. Here is *recognition* of partners, *love*; recognition of *non-partners*, *aversion*; the *union* of the pair owning the roost against the *newcomers*; and *submission* to the results of victory as final on the part of the conquered. Is that not human? Is such behavior conceivable without some intelligence?

That ring-doves remember and recognize each other after a period of separation was illustrated in the case of the two females of “pair D”.¹ I separated these females, giving the larger one as a mate to a white-ring male and putting the other in a cage alone and out of the sight of the first. Nine days after the separation I brought the caged female back to her sister, who was sitting quietly on her eggs. As soon as the dove from the cage saw the sister on the nest she at once gave a laugh of joy and recognition. She flew to the nest, but was repelled by her sister, who was taken by surprise. But after a moment

¹ The complete record is given in Chapter III, under the heading “The Pairing of Two Females.”—EDITOR.

the dove left her eggs, went to the perch, and was at once solicited to act as a male, which she did. There can be no question that this extraordinary conduct meant the fullest recognition on the part of both doves and a memory of their former relations. 26 days later I brought the same female (*D 2*) from the coop behind the house to her sister (*D 1*) in the house. *D 2* seemed to behave as if she still remembered the place and recognized her sister mate, but the latter gave no certain indication of recognition. She soon flew at *D 2* and treated her as an intruder to be driven off as speedily as possible.

Two wild mourning-doves (*Zenaidura*) were captured when 14 to 16 days old. The smaller of the two was placed under the female of pair (*G*) of ring-doves, whose young were 1 week old. Here it passed the night. This bird was about the size of the ring-dove young, but was more feathered and much darker in plumage. When the old birds attempted to feed their young the next day they viewed the new-comer with suspicion and alarm, while it exhibited fear of them. It was then placed with another pair (*C*) of ring-doves, whose young were but 2 days old. At the time of feeding I placed this young in position to feed and the mother fed it abundantly.

The larger of the two young mourning-doves was placed in the pen with the ring-doves, "pair *C*," and both birds exhibited fear. It was then placed in the nest at the time of feeding. Both birds fed it and made no objection to its further presence in the nest. Later this young bird jumped out of the nest onto the floor and the old male then attacked it several times. The bird was then placed with "pair *G*," who fed it when it was introduced into the nest at the time of feeding, but manifested hostility as soon as the feeding was finished, although the bird remained in the nest. This young bird also reacted with a show of hostility to both pairs of these ring-doves, although it eagerly accepted food from them. This manifestation of hostility usually occurred when the foster-parents returned to the nest after a short absence. After 17 days the old birds and the young became accustomed to each other. All signs of fear and hostility disappeared and normal relations were established.

There is evidently some difference between pairs in their capacity to distinguish their own offspring from foreigners. "Pair *C*" was able to distinguish out of the nest but made no distinction within the nest. There is some degree of species reaction, but this can be modified in the course of a few weeks.

A hybrid from a common dove and a Japanese turtle-dove was in a cage containing several other young, among which was a crested pigeon. The hybrid and the crested pigeon sit side by side, fondling each others' head most affectionately; but the hybrid refuses to allow either of the other two birds to come near him. If they approach he attacks with his beak vigorously and they retreat to the perch. It may be that this affection is due to his having had a crested pigeon for a foster-mother. I am more inclined to think so, as this hybrid (and all others from the same parents) is rather quarrelsome and little inclined to make friends with strangers.

A pair of young *Spilopelia tigrina*¹ were placed, at the age of 6 weeks, in a pen with numerous other doves (geopelia, green-wing, white-wing, ring-dove, and two hybrids). They were placed in a nest-box on the right side of the pen and about 2 feet above the floor. They snuggled down here, in preference to sleeping on the edge of the box, so as to keep warm. I placed with them a young hybrid from the common dove and Japanese turtle-dove, which was a cripple in one leg. All three made friends and slept together. Ever after these same birds have invariably sought this same nest-box at night, and to-night they are together *inside the box*. The young *tigrina* know their hybrid companion, and he knows them, and all three of them will attack the other hybrids or the ring-doves, if the latter try to roost on their box. Sometimes the hybrid companion attacks the two

¹ It is possible that these young were *Spil. suratensis*.—EDITOR.

tigrina; these have learned never to resist him, but simply hang their heads and keep still until he stops, which he does after a peek or two. These tiger turtle-doves thus seem: (1) to distinguish between a warm and a cooler place; (2) to distinguish companions from other associates; (3) to know when it is safe to attack and when not. All this points to considerable intelligence. (R 7, SS 10, R 9.)

IMITATION.

It is wonderful how much and how quickly doves learn by imitation. The first young of a pair of ring-doves were placed on the floor of the cage very early and were walking about at the age of 2 weeks. These little fellows had seen their parents "jump" at doves in adjoining cages, on either side, whenever those doves came near and attempted to put their heads through the holes of the wire net. Likewise, these young, before they could walk properly, would perform the same jump and drive away outsiders. It was most amusing to watch them.

My dwarf pigeons (smaller *geopelia*) for a long time utterly refused to take any notice of bread crumbs. I let them go hungry for a while and then fed them only fine crumbs of bread. One of them tried a bit, tested it several times, and finally swallowed it; then he took several more pieces, and finally decided that it was good. Another one, seeing him pick up the crumbs, *put his head close down to him and looked at him* as he took in the bread, and then tried it himself; and so it went until all learned, and in a day or two they would all eat bread with avidity. If one bird is let out of the cage into my room the other dwarfs see this and at once become very uneasy and try hard to get out also. At 2 weeks of age, the first or second day after the young get out of the nest, they usually learn to pick up seed and bread crumbs if these are placed near them; but they are almost invariably, if not always, led to do this by seeing the parents eat. The parental example is the guiding stimulus.

It is very amusing to see young just out of the nest for the first time undertake police duty, which they do by imitation. One of a pair of young ring-doves, for example, out of the nest yesterday, exhibited himself to-day as a most valiant defender of the camp. He would drop his head a little, look a moment at the intruders from another pen as they put their heads through the wire netting to steal seed; then he would "jump" in the most approved fashion, and rush at them with such an air of authority as to frighten them off. This fellow kept up this exhibition for some 10 minutes, and seemed to enjoy the business. It tried the same method on its own brother and sister, who were a month or so older, and several times jumped so vigorously as to land on the back of the dove aimed at. The parents had been seen to do this often, and no doubt the little fellow was doing what he had seen and remembered. I noticed that it did not try to drive its parents, but when they came around it began to tease them for food.

It is a curious fact that when a dove sees its mate feeding the young it is often moved by sympathy to go through the motions of feeding. This may very often be seen in ring-doves. Moreover, when one dove sees another eating it is often thereby stimulated to go and eat also. The same is true with the act of bathing or sunning. If one young dove begins to play, by flapping its wings and skipping, the others are apt to be incited to join in. Old birds often manifest sympathy if they see their young act as if suffering, or if their young are handled roughly. The cry of terror sets every dove within hearing on edge. (R 17.)

EFFECTS OF EXPERIENCE.

Indisputable evidence of *memory* is shown by pigeons when they forsake a roosting-place which has been found to be liable to danger from cats, men, or other enemies. Pigeons are very constant to their chosen roosting-places, but when once molested in these they do not forget it the next night. Handle a pigeon roughly and it becomes wild; *it remembers that you are dangerous, and tries to keep out of reach.*

In the young dove an act once done seems indelibly stamped into the organization. An interesting illustration recently came under my observation. From seeing the parents eat, one of the first young of a pair of ring-doves had, at about 2 weeks of age, *just learned to pick up little bits of bread*. The movements of the mandibles consisted, of course, of first *opening* and then *closing*. This movement was learned. I presented a dish of water to the bird and it put its beak into it and finding it to be something it wanted, it *tried to drink*. But instead of keeping its beak in the water and drinking continuously as the old ones do, it opened its beak and then closed it, *just exactly as if picking up a piece of bread*, and then lifting its beak out of the water, it raised its head as if to let the water run down its throat as a hen does. This curious behavior occurred several times over, just after the bird had, *for the first time*, picked up crumbs of bread. The act of picking—opening and closing the beak—had already become impressed on the creature so strongly that for the time it determined the *method of drinking*, though the acquired method was quite unlike the normal. The next day this bird had learned to drink like its parents.

A young bird, about 4 weeks old, was once taken into the house for hand-care, as the parents did not appear to be feeding it sufficiently. This bird, though unable to fly, learned in a few minutes to pick up seed while with its parents on the ground of the pen. The interesting point is that after being removed from the parents, and while alone and picking up seed for itself, it keeps up squealing and frequent wagging of its wings, as it does when teasing the old birds to feed it. These acts have been so long coördinated with feeding that by force of habit—after the use is passed—the bird continues them.

When adult pigeons (5 to 6 months old) are first turned loose in the open, after having always been kept in a pen, it is curious to see how awkward they are about flying. If they fly up on the roof of a three-story house and then want to get back they look over the roof-edge and seem to shrink from the attempt, as a person would shrink from jumping at a great height. If they get up the courage to try it, after seeing another bird do it, they invariably fly off on the horizontal or near it, not having yet learned to throw themselves downward fearlessly. After they have *learned* that they can do it and not fall or get harmed, they dive down gracefully in perfect confidence.

The relation of lack of experience to the matter of flying in young pigeons is illustrated in the following case: A young homer hybrid, about 5 weeks old, flew for the first time from his cot-opening to a distance of about 25 feet—across to the railing on the back stairs of an adjoining house. The male parent accompanied it. I went up these stairs and, approaching it slowly, keeping one hand in front of it and the other behind it, easily captured it. Why did it not fly before I cornered it? Evidently because it did not feel sure on the wing, and therefore hesitated until I had time to intercept its chances of escape. It had not been handled, and surely wished to escape; and had not my hands been in its way it probably would have flown. The young dove, then, stands like a child, unacquainted with the world and *inexperienced* in the use of its powers. It hesitates to fly from fear and from lack of knowing where it can go for safety.

Doves learn, and learn quickly, to measure their chances against different competitors. For example:

(1) A large dove will generally refuse to budge for a smaller one. The sense of strength is felt by the larger bird. With young birds the case is different, for all young birds are submissive and non-resistant.

(2) The victor often follows up his victory, becomes more domineering, more encroaching. Power is learned by experience.

(3) Some small birds show their superiority by imposing on larger birds; *e.g.*, the case (given elsewhere) of some small geopelias and the large white-faced pigeon. Again, the common mourning-dove is often quite keen in frightening off other doves by sudden jumps or flirts of the wings.

(4) A common pigeon mated with a small ring-dove shows great care in mounting its mate, apparently fearing to injure or treat it roughly.

(5) A male dove, when it sees another male in the act of soliciting or mounting its mate, appears to understand instantly what the purpose is, and often makes frantic efforts to intercept this act, giving the danger signal in the loudest and most excited form and flying directly at the offending bird.

An archangel brings straws from the yard and, in reaching his nest, goes in at a door *B*, which is kept open, and then jumps off the partition *C* to get to the nest. The first egg was already laid; the door *B* had been open during all the time of preparing the nest, but the door *A*, which led directly to the nest, was kept closed. He had learned the indirect way completely. I opened *A* while he was off after a straw; when he returned he went through *A*, taking the direct way rather than the indirect. He did this the first time the opportunity was presented, and repeated the same the second time. The third time he entered at *B*, apparently from habit and not noticing that *A* was open.

Obedience to impulse, or dependence upon it at all times, conduces to its power; *i. e.*, yielding to its promptings makes its promptings absolute master. These promptings are the voice of instincts. Perhaps the extraordinary *keenness of the sense-organs* is due largely to the *obedient attention given to their messages*. Obedience is practically complete; the connection between ingoing message and outgoing response becomes strong and inviolable. The instinctive act follows the signal given. The signals are literally watched for and the acts are fitted to them. If we continually listened to and depended upon our instincts, they would soon control and exclude judgment or reason. If we followed our senses as animals do we should have keener senses. (R 7, R 17.)

INSTINCT AND INTELLIGENCE.

In order to see how instinctive action may graduate into intelligent action it is well to study closely animals in which the instincts have attained a high degree of complexity and in which there can be no doubt about the automatic character of the activities. These conditions are perfectly fulfilled in the pigeons, a group in which we have the further advantage that wild and domestic species can be studied comparatively.

It is quite certain that pigeons are totally blind to the meanings which we discover in incubation. They follow the impulse to sit without a thought of consequences; and no matter how many times the act has been performed, no idea of young pigeons ever enters into the act.¹ They sit because they feel like it, begin when they feel impelled to do so, and stop when the feeling is satisfied. Their time is generally correct, but they measure it as blindly as a child measures its hours of sleep. A bird that sits after failing to lay an egg, or after its eggs have been removed, is not acting from "expectation," but because she finds it agreeable to do so and disagreeable not to do so. The same holds true of the feeding instinct. The young are not fed from any desire to do them any good, but solely for the relief of the parent. The evidence on this point can not be given here,² but I believe it is conclusive.

But if all this be true, where does the graduation towards intelligence manifest itself? Certainly not in a comprehension of utilities which are discoverable only by human intelligence. Whatever the pigeon instinct-mind contains, it is safe to say that the intelligence is hardly more than a grain hidden in bushels of instinct, and one may search more than a day and not find it.

¹ Professor James (Psychology, II, p. 390) thinks such an idea may arise and that it may encourage the bird to sit. "*Every instinctive act in an animal with memory,*" says James, "*must cease to be 'blind' after being once repeated.*" That must depend on the kind of memory the animal has. It is possible to have memory of a certain kind in some things, while having absolutely none of any kind on other things. That is the case in pigeons, as I feel very sure.

² See Chapter VI.—EDITOR.

EXPERIMENT WITH PIGEONS.

Among many tests, take the simple one of removing the eggs to one side of the nest, leaving them in full sight and within a few inches of the bird on the nest. The bird sees the uncovered eggs, but shows no interest in them; she keeps her position, if she is a tame bird, and after some moments begins to act as if the current of her feelings had been slightly disturbed. At the most she only acts as if a little puzzled, as if she realized dimly a change in feeling. She is accustomed to the eggs and now misses something, she knows not what. Although she does not know or show any care for the eggs out of the nest, she does appear to sense a difference between having and not having.

There is, then, something akin to memory and discrimination, and little as this implies, it can not mean less than some faint adumbration of intelligence. Now this inkling of intelligence, or, if you prefer, this nadir of stupidity, so remote from the zenith of intelligence, is not something independent of and foreign to instinct. It is instinct itself just moved by a ripple of change in the environment. The usual adjustment is slightly disturbed, and a little confusion in the currents of feeling arises which manifests itself in quasi-mental perplexity. That is about as near as I can get to the contents of the pigeon mind without being able, by a sort of metempsychosis suggested by Bonnet, to live some time in the head of the bird.

In this feeble perplexity of the pigeon's instinct-mind, in this "nethermost abyss" of stupidity, there is a glimmer of light, and nature's least is always suggestive of more. The pigeon has no hope of graduating into a *homo sapiens*, but her little light may flicker a little higher, and all we need to know is, how instinct behavior can take one step toward mind behavior. This is the dark point on which I have nothing really new to offer, although I hope not to make it darker.

THE STEP FROM INSTINCT TO INTELLIGENCE.

Some notion of what is involved in the step may be gathered by comparing wild with semi-domesticated and fully domesticated species. These grades differ from each other in respects that are highly suggestive. In the wild species the instincts are kept up to the higher degrees of rigid invariability, while in species under domestication they are reduced to various degrees of flexibility, and there is a correspondingly greater freedom of action, with, of course, greater liability to irregularities and so-called "faults." These faults of instinct, so far from indicating physical retrogression, are, I believe, the first signs of greater plasticity in the congenital coördinations and, consequently, of greater facility in forming those new combinations implied in choice of action.

If we place the three grades of pigeons under the same conditions and test each in turn in precisely the same way, we can best see how domestication lets down the bars to choice and at the same time gives more opportunities for free action. The simplest experiment is always the best. Let us take three species at the time of incubation and repeat with each the experiment of removing the eggs to a distance of 2 inches outside the edge of the nest. The three grades are well represented in the wild passenger-pigeon (*Ectopistes*), the little ring-dove (*Streptopelia risoria*), and the common dove-cote pigeon (*Columba livia domestica*). The results will not, of course, always be the same, but the average will be about as follows:

(1) *The passenger-pigeon*.—The passenger-pigeon leaves the nest when approached, but returns soon after you leave. On returning she looks at the nest, steps into it, and sits down as if nothing had happened. She soon finds out, not by sight, but by feeling, that something is missing. Her instinct is keenly attuned and she acts quite promptly, leaving the nest after a few minutes without heeding the egg. The conduct varies relatively little in different individuals.

(2) *The ring-dove*.—The ring-dove is tame and sits on while you remove the eggs. After a few moments she moves a little and perhaps puts her head down, as if to feel the missing

eggs with her beak. Then she may glance at the eggs and appear as if half consciously recognizing them, but makes no move to replace them, and after 10 to 20 minutes or more leaves the nest with a contented air, as if her duty were done; or, she may stretch her neck toward the eggs and try to roll one back into the nest. If she succeeds in recovering one she is satisfied and again sinks into her usual restful state, with no further concern for the second egg. The conduct varies considerably with different individuals.

(3) *The dove-cote pigeon*—The dove-cote pigeon behaves in a similar way, but will generally try to get *both* eggs back and, failing in this, she resigns the nest with more hesitation than does the ring-dove.

(4) *Results considered*—The passenger-pigeon's instinct is wound up to a high point of uniformity and promptness, and her conduct is almost too blindly regular to be credited even with that stupidity which implies a grain of intelligence. The ring-dove's stupidity is satisfied with one egg. The dove-cote pigeon's stupidity may claim both eggs, but it is not always up to that mark.

In these three grades the advance is from extreme blind uniformity of action, with little or no choice, to a stage of less rigid uniformity, with the least bit of perplexity and a very feeble, uncertain, dreamy sense of sameness between eggs *in* and eggs *out* of the nest, which prompts the action of rolling the eggs back into the nest. That is the instinctive way of placing the eggs when in the nest, and the neck is only a little further extended in drawing the eggs in from the outside. How very narrow is the difference between the ordinary and the extraordinary act! How little does the pendulum of normal action have to swing beyond its usual limit!¹

But this little is in a forward direction, and we are in no doubt as to the general character of the changes and the modifying influences through which it has been made possible. Under conditions of domestication the action of natural selection has been relaxed, with the result that the rigor of instinctive coordinations which bars alternative action is more or less reduced. Not only is the door to choice thus unlocked, but more varied opportunities and provocations arise, and thus the internal mechanism and the external conditions and stimuli work both in the same direction to favor greater freedom of action.

When choice thus enters no new factor is introduced. There is greater plasticity within and more provocation without, and hence the same bird, without the addition or loss of a single nerve-cell, becomes capable of higher action and is encouraged and even constrained by circumstances to *learn* to use its privilege of choice.

Choice, as I conceive, is not introduced as a little deity, encapsuled in the brain. Instinct has supplied the teleological mechanism, and stimulus must continue to set it in motion. But increased plasticity invites greater interaction of stimuli and gives more even chances for conflicting impulses. Choice runs on blindly at first, and ceases to be blind only in proportion as the animal learns through nature's system of compulsory education. The teleological alternatives are organically provided; one is taken and fails to give satisfaction; another is tried and gives contentment. This little freedom is the dawning grace of a new dispensation, in which education by experience comes in as an amelioration of the law of elimination. This slight amenability to natural educational influences can not, of course, work any great miracles of transformation in a pigeon's brain; but it shows the way to the open door of a freer commerce with the eternal world, through which a brain with richer instinctive endowments might rise to higher achievement.

¹ We come to equally surprising results in many different ways. Change the position of the nest box of the ring-dove, without otherwise disturbing bird, nest, or contents, and the birds will have great difficulty in recognizing their nest, for they know it only as something in a definite position in a fixed environment. If a pair of these birds have a nest in a cage, and the cage be moved from one room to another, or even a few feet from its original position in the same room, the nest ceases to be the same thing to them, and they walk over the eggs or young as if completely devoid of any acquaintance with or interest in them. Return the cage to its original place and the birds know the nest and return to it at once.

The conditions of amelioration under domestication do not differ in kind from those presented in nature. Domestication merely bunches nature's opportunities and thus concentrates results in forms accessible to observation. Natural conditions are certainly working in the same direction, only more slowly. The direction and the method of progress must, in the nature of things, remain essentially the same.

Nature works to the same ends as intelligence, and to the natural course of events I should look for just such results as Lloyd Morgan¹ so clearly pictures and ascribes to intelligence: He says

"Suppose the modifications are of various kinds and in various directions, and that, associated with the instinctive activity, a tendency to modify it *indefinitely* be inherited. Under such circumstances *intelligence would have a tendency to break up and render plastic a previously stereotyped instinct*; for the instinctive character of the activities is maintained through the constancy and uniformity of their performance. But if the normal activities were thus caused to vary in different directions in different individuals, the offspring arising from the union of these differing individuals would be imperfect, and there would be an inherited tendency to vary. *And this, if continued, would tend to convert what had been a stereotyped instinct into innate capacity; that is, a general tendency to certain activities (mental or bodily), the exact form and direction of which are not fixed, until by training, from imitation or through the guidance of individual intelligence, it became habitual. Thus it may be that it has come about that man, with his enormous store of innate capacity, has so small a number of stereotyped instincts.*"

The following from Professor James² is suggestive:

"Nature implants contrary impulses to act on many classes of things, and leaves it to slight alterations in the conditions of the individual case to decide which impulse shall carry the day. Thus, greediness and suspicion, curiosity and timidity, coyness and desire, bashfulness and vanity, sociability and pugnacity seem to shoot over into each other as quickly, and to remain in as unstable equilibrium, in the higher birds and mammals as in man. They are all impulses, congenital, blind at first, and productive of motor reactions of a rigorously determinate sort. Each one of them, then, is an instinct, as instinct is commonly defined. *But they contradict each other; experience, in each particular opportunity of application, usually deciding the issue. The animal that exhibits them loses the "instinctive" demeanor and appears to lead a life of hesitation and choice, an intellectual life; not, however, because he has no instincts—rather because he has so many that they block each other's path.*"

Looking only to the more salient points of direction and method in nature's advance towards intelligence, the general course of events may be briefly adumbrated. Organic mechanisms capable of doing teleological work through blindly determined adjustments, reproduced congenitally and carried to various degrees of complexity and inflexibility of action, were first evolved. With the organization of instinctive propensities, liable to antagonistic stimulation, came both the possibility and the provocation to choice. In the absence of intelligent motive, choice would stand for the outcome of conflicting impulses. The power of blind choice could be transmitted, and that is what man himself begins with.

Superiority in instinct endowments and concurring advantages of environment would tend to liberate the possessors from the severities of natural selection; and thus nature, like domestication, would furnish conditions inviting to greater freedom of action, and with the same result, namely, that the instincts would become more plastic and tractable. Plasticity of instinct is not intelligence, but it is the open door through which the great educator, experience, comes in and works every wonder of intelligence.

Spencer³ has shown clearly that this plasticity must inevitably result from the progressive complication of the instincts. He says:

That progressive complication of the instincts which, as we have found, involves a progressive diminution of their purely automatic character, likewise involves a simultaneous commencement of memory and reason.

¹ Animal Life and Intelligence, pp. 452, 453. ² Psychology, II, pp. 392, 393. ³ Psychology, I, pp. 443 and 454, 455.

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